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RESEARCH MEMORANDUM

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U. S. Air Force

INVESTIGATION OF EJECTION RELEASE CHARACTERISTICS OF
FOUR DYNAMICALLY SCALED INTERNAL-STORE SHAPES FROM
A 1/17-SCALE SIMULATED BOMB BAY OF THE REPUBLIC
F-105 AIRPLANE AT MACH NUMBERS OF 1.39 AND 1.98

COORD. NO. AF-222

By John B. Lee

Langley Aeronautical Laboratory
Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

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SUMMARY

An investigation has been conducted in the 27- by 27-inch preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va., of the release characteristics of dynamically scaled stores carried internally in a simulated bomb bay at Mach numbers M_0 of 1.39 and 1.98. A 1/17-scale model of the Republic F-105 half-fuselage and bomb-bay configuration was used with four store shapes. The store shapes were the modified Mk-7 store, the bluff store, the TX-28 store, and the turnabout TX-28 store. Simulated altitudes were 3,400 feet at $M_0 = 1.39$ and 29,000 feet at $M_0 = 1.98$.

Successful ejections were made with the modified Mk-7 store at supersonic speeds at near sea-level conditions by the use of high ejection velocities, by ejecting the store at a negative incidence angle, or by extending the release point of the store. Poor release characteristics were obtained at a positive fuselage angle of attack for the Mk-7 store. The bluff store was successfully released at supersonic speeds at low and high altitudes and at a positive fuselage angle of attack. Small changes in pitch oscillations and ejection velocities have a large influence on the Mk-7 store trajectory, whereas the changes in the bluff-store trajectory are small with large changes in pitch oscillations and ejection velocities. The TX-28 store was unstable with the fin configuration of the present report. Excellent release characteristics were obtained with the turnabout TX-28 store at supersonic speeds and near sea-level conditions.

INTRODUCTION

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This investigation was made by using 1/17-scale models in the preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va. The dynamically scaled stores simulated altitudes of 3,400 feet at a Mach number of 1.39 and 29,000 feet at a Mach number of 1.98 at Reynolds numbers of 8.87×10^6 and 14.63×10^6 per foot, respectively. The investigation was of an exploratory nature to determine which modifications were necessary to obtain successful releases with the Mk-7 store and to determine if additional store shapes could be successfully used in the present Republic F-105 designed bomb bay with perhaps only small modifications in the store shapes.

An investigation of the release characteristics of the Mk-7 store, with a high-aspect-ratio, sweptback, three-fin configuration, from a simulated bomb bay of the F-105 has been reported in reference 1. Successful releases at a Mach number M_0 of 1.4 simulating near sea-level conditions could not be made without modifications of the store fins. For the present investigation of the Mk-7 store, several modifications were made in the original store as suggested by the National Advisory Committee for Aeronautics and Republic Aviation Corporation. The fins were made stronger by doubling their thickness. Some tests were made with dorsal-type fins and also fins with a 33-percent increase in fin area. The tail cone of the store was removed for some tests. Tests were made with ejection velocities of 30 and 45 feet per second at $M_0 = 1.39$ simulating a 3,400-foot altitude.

An investigation was made of a Wright Air Development Center (WADC) bluff store with a ratio of length to diameter l/d of 2.58 at $M_0 = 1.39$ and $M_0 = 1.98$ simulating 3,400 and 29,000 feet, respectively. This store was investigated as a possibility of a smaller store package with a high drag and a relatively low lift-curve slope; both of these factors tend to produce small changes in store trajectories with large pitch oscillations. Some tests of similar shapes have been reported in reference 2.

Shape TX-28 with $l/d = 8.5$, similar to the store shape reported in reference 3 but with a lower aspect ratio, three-fin configuration, was also tested.

A turnabout TX-28 store with $l/d = 4.48$, a blunt ogive nose, and a low-aspect-ratio wedge-type fin was also tested. This store was relatively compact, with higher drag and increased stability over the streamlined store.

The method of dynamic simulation used has been discussed in references 1, 3, and 4. Trajectories obtained by using static-force test results are compared with those obtained in dynamic model tests in reference 5.

SYMBOLS

d	diameter, in.
h_p	simulated altitude, ft
i_o	store incidence angle at start of ejection stroke, deg
I_y	moment of inertia of store in pitch plane, lb-in. ²
l	store length, in.
L	characteristic length, in.
m	mass
M_o	free-stream Mach number
q_o	free-stream dynamic pressure, lb/sq ft
p	free-stream static pressure, lb/sq ft
t	time, milliseconds
w	store weight, lb
x/d	horizontal distance in terms of store diameter from store-release point
z/d	vertical distance in terms of store diameter from store-release point
\dot{z}_o	store-ejection velocity, ft/sec
ρ	air density, slugs/cu ft
D	store density, slugs/cu ft
α_f	angle of attack of airplane fuselage, deg
θ_s	store pitch angle in reference to undisturbed free-stream direction, deg

Subscripts:

m model

p prototype

MODELS AND APPARATUS

Stores

The basic store body configurations are shown in figure 1, and the store ordinates are shown in table I.

As previously shown in reference 1, the fins for the Mk-7 store models were too flexible. For this investigation the fins were made of magnesium and the thickness of the fin was doubled for the near sea-level ejections (fig. 2(a)). This fin is referred to as the standard fin for the present investigation. For the full-scale model the resulting weight increase due to the heavier fins caused a rearward shift of the store center of gravity. The tail cone of the store was removed at station 8.647 (station 147 full scale) to move the center of gravity forward. Figure 2(b) shows the dorsal-type fin and figure 2(c) shows a fin with a 33-percent increase in fin area used on the modified Mk-7 store.

The bluff store (fig. 1(b)) had the same store diameter as the Mk-7 store and had a fineness ratio of 2.58. The bluff store is of interest because the lift and drag are relatively insensitive to changes in angle of attack. Unpublished static data by the Wright Air Development Center show that $C_D = 1.5$ at $\theta_s = 0^\circ$ and 1.8 at $\theta_s = 16^\circ$ and that $C_L = 0.29$ at $\theta_s = 16^\circ$ at a Mach number of 1.5. These coefficients are based on body frontal area.

The TX-28 store was a store of smaller diameter with a fineness ratio of 8.5 (fig. 1(c)). The fin used for the TX-28 store is shown in figure 3. This low-aspect-ratio three-fin configuration was used in an attempt to obtain a fin that could be stored in the present bomb-bay configuration without having to fold the fins. Successful store ejections of a similar store shape with higher aspect-ratio fins have been reported in reference 3.

The turnabout TX-28 store shape shown in figure 1(d) had the same store diameter as the TX-28 but a fineness ratio of 4.48. The nose of the store had an ogive and was blunted. The store had a low-aspect-ratio, wedge-type, four-fin configuration. The fin configuration and dimensions are shown in figure 4. Figure 5 shows photographs of the

Mk-7 store with the different fin configurations tested. Figures 6, 7, and 8 are photographs of the bluff store, the TX-28 store, and the turnabout TX-28 store, respectively.

In order to scale properly the weights and inertias to simulate a 3,400-foot altitude, the Mk-7 and TX-28 store bodies were made of balsa with steel cores and the fins were made of magnesium. The bluff store also had a balsa body and a steel core. For the turnabout TX-28, the nose and tail fins were made of titanium, and the body, of balsa with a tungsten core. In order to simulate 29,000 feet with the bluff store, the body was made of magnesium and the core of tungsten.

The store weights and inertias were simulated within ± 5 percent.

Fuselage and Bomb Bay

The 1/17-scale model of the Republic F-105 fuselage and bomb bay used for these tests has been described previously in reference 1.

Ejection Cylinder

Store ejection was accomplished through the use of an ejection cylinder. Ejection cylinder 1 as described in reference 1 was used for some of the tests. Some of the tests were also performed with a modified ejection cylinder, or cylinder 2 as shown in figure 9. This cylinder had the same stroke length of 1.76 inches as cylinder 1. The ejection rod was made larger and stronger, and by placing the locking balls up in the cylinder, springs could be attached to bottom of the ejection rod. By modifying the head of the store release pin to a hemisphere, the springs would lock around the pinhead when the cylinder was in a locked position. The sway brace could be removed and the model would be free to pitch and yaw during its ejection stroke. This type of ejection is referred to as an unguided stroke, and when the sway brace was used, as a guided stroke. The length of the ejection stroke was changed by interchanging the caps, with different rod lengths, at the top of the ejection rod. The rod-assembly release pin fitted into the recess in the rod cap and this pin was actuated by the solenoid valve. Near the bottom of the ejection stroke (fig. 9(b)), the locking balls released the rod assembly and the inner rod was allowed to travel far enough to allow the springs to release the store pin.

The sway braces were interchangeable for the different stores tested. For the unguided stroke an adapter without a sway brace 8(b) (fig. 9(a)) was used.

Preflight Jet

All tests were made in the 27- by 27-inch preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va. (ref. 6), in which the stagnation pressures and temperatures could be varied. The Mach number of the test was changed by use of interchangeable nozzle blocks. The test setup has been shown in reference 1.

Test Methods

A description of the store ejection and the photography technique used has been given in references 1, 2, and 3.

Successful releases were made with the Mk-7 store at $M_0 = 1.98$, simulating a 29,000-foot altitude as reported in reference 1. All tests in the present investigation of the Mk-7 store were made at $M_0 = 1.39$, simulating a 3,400-foot altitude, and with a full guided stroke. Some test results from reference 1 have been repeated where it was deemed necessary for comparisons. The store was ejected at 30 and 45 feet per second with store incidence angles of $i_0 = 0^\circ$ and -4° . Ejections were also made at fuselage angles of attack of 0° and 3° . The fuselage angle of attack was 0° for all tests unless otherwise noted.

The bluff-store shape was tested at $M_0 = 1.39$ and 1.98, simulating 3,400 feet and 29,000 feet, respectively. The store was ejected over a range of ejection velocities \dot{z}_0 from 12.5 to 34.5 feet per second. Ejections were made with guided and unguided strokes and for stroke ratios of 50 percent, 75 percent, and 100 percent of the full stroke length. The store position at the start of the stroke was the same in all cases, but the release point changed with the stroke ratio. For both the Mk-7 store and the bluff store, the ejection force was through the center-of-gravity point of the store.

Ejections of the TX-28 store were made at $M_0 = 1.39$, simulating 3,400 feet, with $\alpha_f = 0^\circ$, $i_0 = -4^\circ$, and at ejection velocities of 34 and 46 feet per second with a full guided stroke. The point of the ejection force was 6.5 percent of the store length ahead of the center-of-gravity point (fig. 1(c)).

The turnabout TX-28 was tested at $M_0 = 1.39$, simulating 3,400 feet at $\alpha_f = 0^\circ$, $\dot{z}_0 = 30$ feet per second, and at store incidence angles of 0° and -4° with a full guided stroke. The point of the ejection force was 3.25 percent of the store length ahead of the center-of-gravity point (fig. 1(d)).

RESULTS AND DISCUSSION

Ejection Photographs

Table II lists the tests and the pertinent data of each test. Figure 10 presents Strobolight pictures of ejections reported previously in reference 1 for comparisons with tests of the present investigation. Figure 11 presents results for the modified Mk-7 store with the tail cone removed and 0.10-inch-thick magnesium fins. Ejections of the bluff store are shown in figures 12 and 13 at $M_0 = 1.39$ and 1.98, respectively. Figures 14 and 15 are ejection photographs of the TX-28 and the turnabout TX-28, respectively, at $M_0 = 1.39$, simulating a 3,400-foot altitude.

Data Plots

Figures 16 to 22 are data plots of the ejected stores. The pitch angle θ_s is plotted against time in milliseconds. The trajectory of the stores center-of-gravity point is plotted in terms of the store diameter. The point of release of the store is zero time. The data symbols close to impact are darkened if the store strikes the bomb bay or fuselage.

Mk-7 Store Ejections

A comparison of the ejection release characteristics of the modified store with the original store (previously reported in ref. 1) using ejector 1 at $\dot{z}_0 = 30$ feet per second is shown in figure 16(a). The release point of the store was extended by $z/d = 0.418$, the advantage of which has been shown also in reference 1. The modified store (test 4), pitched to only $\theta_s = 12^\circ$, stabilized, and did not obtain enough lift to strike the fuselage as was the case with the original store (test 3). The difference in store pitch angle at release is probably due to increased flexibility in the ejection rod after repeated use. An ejection of the original store with the modified ejector (ejector 2) was not made, so a comparison of ejectors cannot be made. The change in flow field due to change in ejectors is probably very small. An advantage of ejector 2 was that the store was released within 2.5° of the preset incidence angle, whereas for ejector 1 the store angle changed as much as 6° from the preset incidence angle.

Figure 16(b) shows the advantage of stiffer fins (test 2) and stiffer fins with the tail cone removed (test 5). The release of the modified store, although greatly improved, was not satisfactory at $\dot{z}_0 = 30$ feet per second, $\alpha_f = 0^\circ$, and $i_0 = 0^\circ$ from the normal release point.

The store-ejection velocity was increased to 45 feet per second in test 6 (fig. 16(c)), and a favorable release was obtained with a maximum $\theta_s = 12^\circ$.

The store incidence angle was changed to $i_o = -4^\circ$ (fig. 16(b)) and a favorable release was obtained at $\dot{z}_o = 30$ feet per second. The vertical velocity of the store became zero in 1.5 store diameters from the fuselage and the store proceeded to fly level. Increasing the ejection velocity to 45 feet per second allowed the store to continue its downward ejection velocity. The store was ejected at 30 and 45 feet per second with its fins folded (fig. 16(d)). It appears from the store oscillation curves (fig. 16(d)) that the store fins should be opened in less than 4 milliseconds (model scale time) for the store to follow approximately the same pitch trajectory as with the fins-open drops. If the fins are not opened, the store will strike the bomb bay even with the high ejection velocities.

A comparison of fin modifications is shown in figure 16(e) for $\alpha_f = 0^\circ$ and $i_o = -4^\circ$. Adding dorsal fins to the standard fin or increasing the fin area showed little or no improvement in ejection characteristics.

Increasing the fuselage angle of attack to 3° (test 15, fig. 16(f)) caused poorer release characteristics. The fuselage angle of attack had a greater effect on the store pitch oscillations than a change in the store incidence angle. Higher initial pitch angles were reached at $\alpha_f = 3^\circ$ and $i_o = -4^\circ$ than at $\alpha_f = 0^\circ$ and $i_o = 0^\circ$.

Because of the high lift forces obtained by the store, its trajectory varies greatly with changes in pitch angle and ejection velocities.

Bluff Stores

Successful ejections were made of the bluff store as can be seen from the Strobolight pictures of the drops (fig. 12, tests 16 and 27).

Figures 17(a) and (b) show that successful ejections were made at both fuselage angles of attack of 0° and 3° at $M_o = 1.39$ at near sea-level conditions and at $M_o = 1.98$ at 29,000 feet. Although the Mk-7 store had a nose-up tendency at release, the bluff store had a nose-down pitching motion at release, probably a result of its flat or bluff nose. Even with a change in bomb-bay angle of attack and changes in the stores pitch amplitudes, the store trajectory was almost identical. This insensitivity of the trajectory to pitch amplitude is due to the fact that the lift and drag are relatively unaffected by store angle of attack as noted previously in the "Model and Apparatus" section.

From the store pitch-time curve it can be seen that the store pitch amplitude increases with time. This is probably due to the trajectory of the store through the disturbed flow field and the poor damping characteristics of the store.

In figure 18 the ejection velocity of the store was increased from 24.5 to 34.5 feet per second. By increasing the ejection velocity, the initial portion of the pitch trajectory was improved but then the store pitched to high pitch angles. In reference 2 it was shown that the store trajectory through a disturbed flow field influenced the pitch trajectory, and that the ejection velocity could be changed to obtain the best pitch trajectory.

Tests were made for ejection releases for unguided strokes in which the sway brace was eliminated and the store was free to pitch during its ejection stroke. Figure 19 shows that higher maximum pitch amplitudes were obtained for the guided full stroke than with the unguided full stroke. The guided stroke for both altitudes and Mach numbers was decreased to 0.75 and the maximum pitch oscillations were decreased. For the three-quarter stroke, the sway brace and rod were not projecting into the airstream. It is thus apparent that the rod and sway brace projecting into the airstream had a large effect on the high pitch oscillations of the stores.

Several attempts were made at $M_0 = 1.39$ and $h_p = 3,400$ feet and at $M_0 = 1.98$ and $h_p = 29,000$ feet to eject the store at $\dot{z}_0 = 12.5$ feet per second with a full guided stroke. The store remained on the sway brace until the tunnel dynamic pressure was reduced for all tests except test 21, for which small pitch oscillations were obtained (fig. 12). However, for a one-half guided stroke, high pitch oscillations were obtained for both Mach numbers and altitudes. It is thus important to find the best combination of ejection velocities, stroke lengths, and type of stroke, guided or unguided, to obtain the most favorable pitch trajectory.

Shape TX-28

Tests were made of shape TX-28 at $M_0 = 1.39$ and $h_p = 3,400$ feet (fig. 14). The store was ejected at $i_0 = -4^\circ$ with the push point ahead of the center-of-gravity station. The store was ejected at 34 and 46 feet per second but, in each case, the store pitched to a high positive angle of attack and became unstable (fig. 21). In reference 2, larger fins were used and the store remained stable. The fin size for the present investigation was limited by the bomb-bay size.

Turnabout TX-28

The turnabout TX-28 store was ejected at $\dot{z}_0 = 27.5$ feet per second and at $\alpha_f = 0^\circ$ and $i_0 = 0^\circ$ and -4° (fig. 15). Excellent release characteristics were obtained. The store pitched to a maximum angle of 5° and stabilized. When the store was ejected at a negative incidence angle, it pitched to a positive angle of attack of 4° and followed a similar pitch trajectory as the 0° incidence release (fig. 22). A similar result was shown in reference 2 in which a fuselage and wing combination was used.

CONCLUSIONS

As a result of the investigation of store ejections from the simulated bomb bay of the Republic F-105 airplane at Mach numbers of 1.39 and 1.98, the following conclusions are indicated:

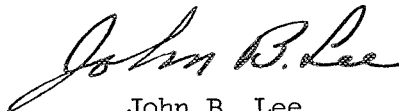
1. Successful ejections of the modified Mk-7 store can be made at near sea-level conditions by the use of high ejection velocities, by ejecting the store at a negative incidence angle, or by extending the release point of the store.
2. The use of dorsal-type fins or increasing the fin area showed little or no improvement in the release characteristics of the modified Mk-7 store having standard fins.
3. A positive fuselage angle of attack caused poor release characteristics of the modified Mk-7 store.
4. The fins should be opened in 4 milliseconds (0.068 second full scale) after release to stabilize the Mk-7 store.
5. Successful releases can be made with the bluff store at low altitudes and low Mach numbers and at high altitudes and high Mach numbers at a positive fuselage angle of attack.
6. Release characteristics of the bluff store were improved by decreasing the ejection stroke so that the sway brace did not project into the airstream, or by the use of an unguided stroke in which the sway brace was eliminated.
7. For the bluff store, decreasing the length of the ejection stroke and reducing the ejection velocity caused high pitch oscillations, but the airplane was not endangered.

8. Small changes in pitch oscillations and ejection velocities have a large influence on the Mk-7 store trajectory, whereas even large changes in pitch oscillations and ejection velocities have little effect on the trajectory of the bluff store.

9. The TX-28 store was unstable in the vicinity of the bomb bay with the present fin configuration.


10. Excellent release characteristics were obtained with the turn-about TX-28 store.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., September 11, 1956.



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Approved:



Joseph A. Shortal
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TABLE I.- STORE ORDINATES

[All dimensions are in inches]

Mk-7 store; $l/d = 6.00$		TX-28 store; $l/d = 8.5$		Turnabout TX-28 store; $l/d = 4.48$	
Station	Radius	Station	Radius	Station	Radius
0.088	0.208	0	0	0.618	0.579
.206	.315	.059	.064	.912	.586
.324	.391	.353	.185	1.206	.588
.515	.487	.647	.274	2.618	.588
.687	.555	.941	.344	2.912	.583
.860	.612	1.235	.398	3.206	.570
1.033	.661	1.529	.440	3.500	.552
1.206	.704	1.824	.475	3.794	.530
1.794	.811	2.118	.504	4.088	.504
2.088	.847	2.412	.530	4.382	.475
2.382	.874	2.706	.552	4.676	.440
2.676	.890	3.000	.570	4.971	.398
2.971	.897	3.294	.583	5.265	.344
4.559	.897	3.588	.588		
5.077	.890	5.000	.588		
5.595	.869	5.294	.586		
6.113	.835	5.588	.579		
6.632	.789	5.882	.567		
7.161	.730	6.176	.551		
7.670	.654	6.470	.531		
8.187	.577	6.765	.508		
8.706	.488	7.059	.481		
8.941	.444	7.353	.451		
10.765	.000	7.650	.419		
		7.941	.384		
		8.235	.348		
		8.529	.310		
		10.000	.115		
L.E. radius, 0.248					
T.E. radius, 0.108					

TABLE II.- TEST SEQUENCE

Test	Figure	Shape	Test conditions							Model conditions					Remarks
			M ₀	h _p , ft	z ₀ , ft/sec	α _f , deg	i ₀ , deg	Ejector	w, lb	I _y , lb-in. ²	Center of gravity		Fins		
											in.	percent			
1	10(a)	Mk-7	1.40	3,400	30.0	0	0	1	0.400	1.414	3.711	34.5	See remarks	Reference 1; 0.05-inch-thick magnesium fins Reference 1; 0.05-inch-thick aluminum fins Reference 1; 0.05-inch-thick magnesium fins; release point extended z/d = 0.418 Release point extended z/d = 0.418	
2	10(b)	Mk-7	1.40	3,400	30.0	0	0	1	.449	2.036	4.130	38.4	See remarks		
3	10(c)	Mk-7	1.40	3,400	30.0	0	0	1	.400	1.418	3.716	34.5	See remarks		
4	11(a)	Mk-7	1.39	3,400	30.0	0	0	1	.394	1.360	3.705	34.5	Standard	Repeat of test 8	
5	11(b)	Mk-7	1.39	3,400	30.0	0	0	2	.389	1.360	3.707	34.5	Standard		
6	11(c)	Mk-7	1.39	3,400	45.0	0	0	2	.384	1.360	3.727	34.6	Standard		
7	11(d)	Mk-7	1.39	3,400	30.0	0	-4	2	.386	1.360	3.718	34.5	Folded		
8	11(e)	Mk-7	1.39	3,400	30	0	-4	2	.394	1.360	3.705	34.5	Standard		
9	11(f)	Mk-7	1.39	3,400	30	0	-4	2	.388	1.460	3.714	34.5	Standard		
10	11(g)	Mk-7	1.39	3,400	45	0	-4	2	.388	1.360	3.719	34.5	Folded		
11	11(h)	Mk-7	1.39	3,400	45	0	-4	2	.384	1.360	3.731	34.7	Standard		
12	11(i)	Mk-7	1.39	3,400	30	0	-4	2	.381	1.460	3.726	34.6	Dorsal		
13	11(j)	Mk-7	1.39	3,400	45	0	-4	2	.390	1.520	3.697	34.3	Dorsal		
14	11(k)	Mk-7	1.39	3,400	45	0	-4	2	.388	1.520	3.687	34.3	33 percent fin area increase		
15	11(l)	Mk-7	1.39	3,400	30	3	-4	2	.380	1.460	3.726	34.6	Standard		
16	12(a)	Bluff	1.39	3,400	24.5	0	0	1	.407	.430	1.600	34.6	Full guided stroke		Full guided stroke Full guided stroke Full guided stroke Three-quarter guided stroke Full unguided stroke Full guided stroke One-half guided stroke
17	12(b)	Bluff	1.39	3,400	25.0	3	0	1	.407	.435	1.600	34.6	Full guided stroke		
18	12(c)	Bluff	1.39	3,400	33.5	0	0	2	.408	.397	1.610	35.0	Full guided stroke		
19	12(d)	Bluff	1.39	3,400	34.5	0	0	2	.412	.435	1.610	35.0	Three-quarter guided stroke		
20	12(e)	Bluff	1.39	3,400	34.5	0	0	2	.411	.444	1.610	35.0	Full unguided stroke		
21	12(f)	Bluff	1.39	3,400	12.5	0	0	2	.411	.426	1.590	34.4	Full guided stroke		
22	12(g)	Bluff	1.39	3,400	12.5	0	0	2	.404	.388	1.620	35.1	One-half guided stroke		
23	13(a)	Bluff	1.98	29,000	26.5	0	0	1	1.132	1.245	1.600	34.6	Full guided stroke	Full guided stroke Full guided stroke Three-quarter guided stroke Full unguided stroke One-half guided stroke	
24	13(b)	Bluff	1.98	29,000	26.0	3	0	1	1.136	1.245	1.610	35.0	Full guided stroke		
25	13(c)	Bluff	1.98	29,000	28.0	0	0	2	1.142	1.270	1.610	35.0	Three-quarter guided stroke		
26	13(d)	Bluff	1.98	29,000	23.5	0	0	2	1.134	1.270	1.620	35.1	Full unguided stroke		
27	13(e)	Bluff	1.98	29,000	12.5	0	0	2	1.140	1.270	1.590	34.4	One-half guided stroke		
28	14(a)	TX-28	1.39	3,400	34.0	0	-4	1	.386	1.182	4.411	44.1	Unstable in vicinity of bomb bay	Unstable in vicinity of bomb bay Unstable in vicinity of bomb bay	
29	14(b)	TX-28	1.39	3,400	46.0	0	-4	1	.395	1.182	4.432	44.3	Unstable in vicinity of bomb bay		
30	15(a)	Turnabout	1.39	3,400	27.5	0	0	1	.414	1.184	2.117	40.1			
31	15(b)	Turnabout	1.39	3,400	27.5	0	-4	1	.418	1.184	2.120	40.3			

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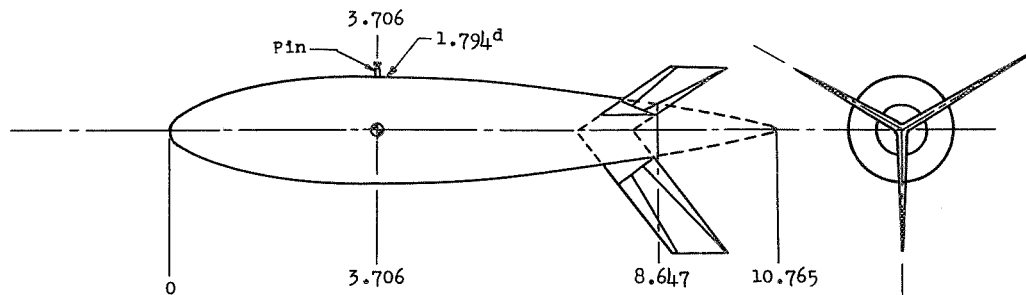
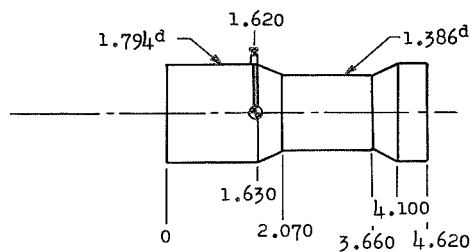
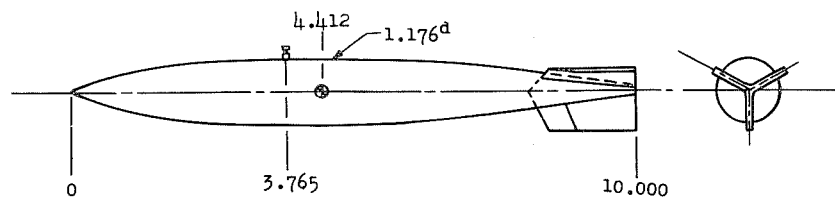
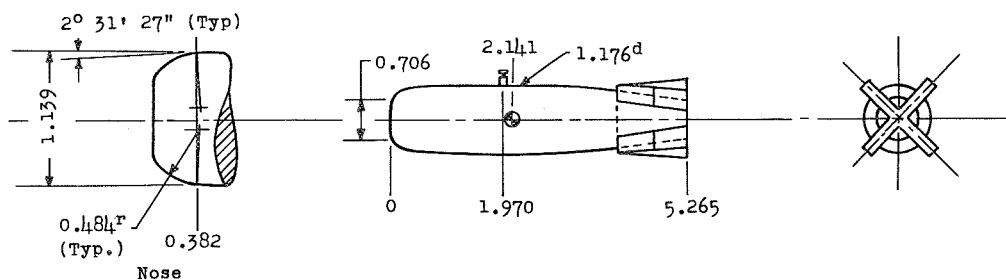
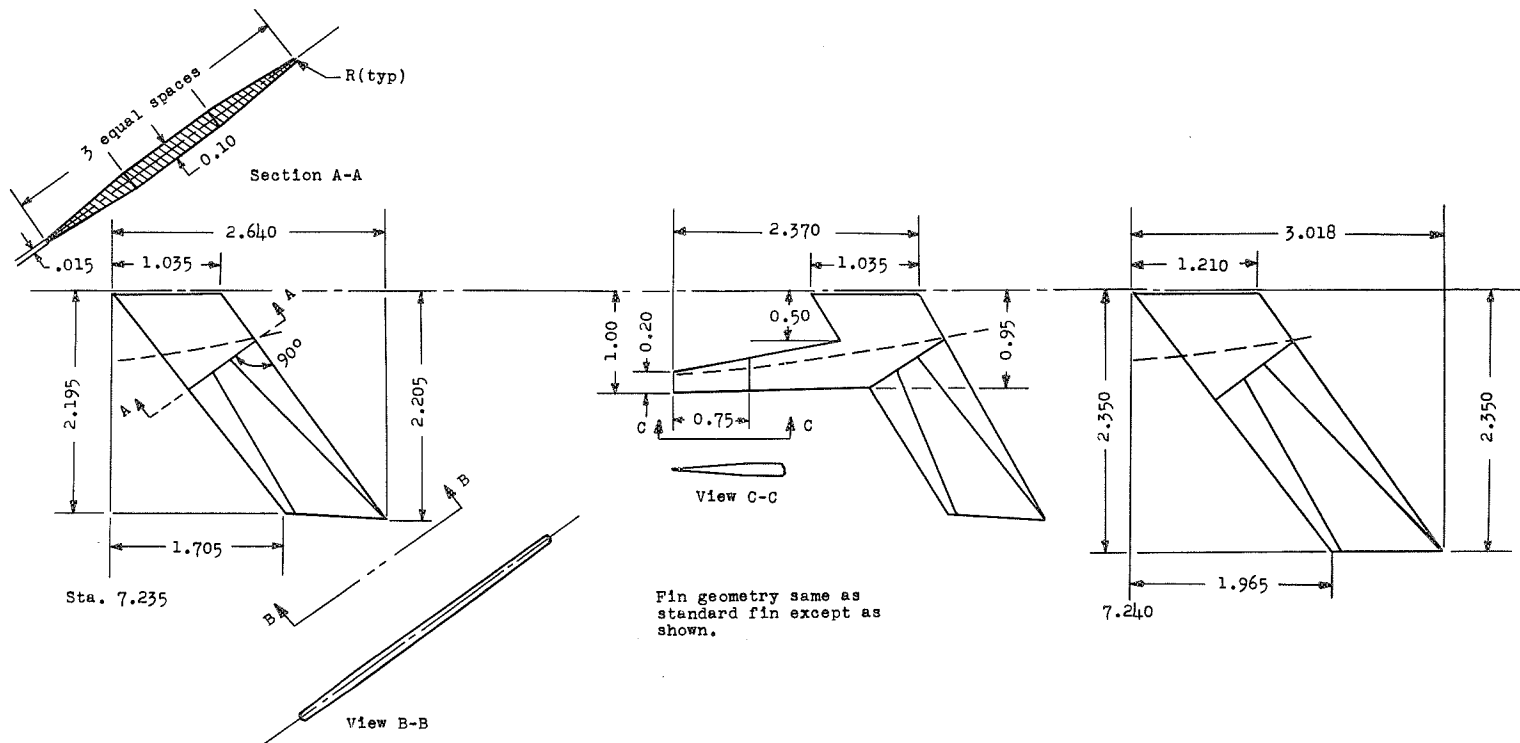
(a) Modified Mk-7 store; $l/d = 6.00$.(b) Bluff store; $l/d = 2.58$.(c) TX-28 store; $l/d = 8.5$.(d) Turnabout TX-28; $l/d = 4.48$.

Figure 1.- 1/17-scale models of Republic F-105 stores. All dimensions are in inches.



(a) Standard fin.

(b) Dorsal fin.

(c) 33-percent increase in fin area.

Figure 2.- Mk-7 store fin configurations and dimensions. All dimensions are in inches (model scale).

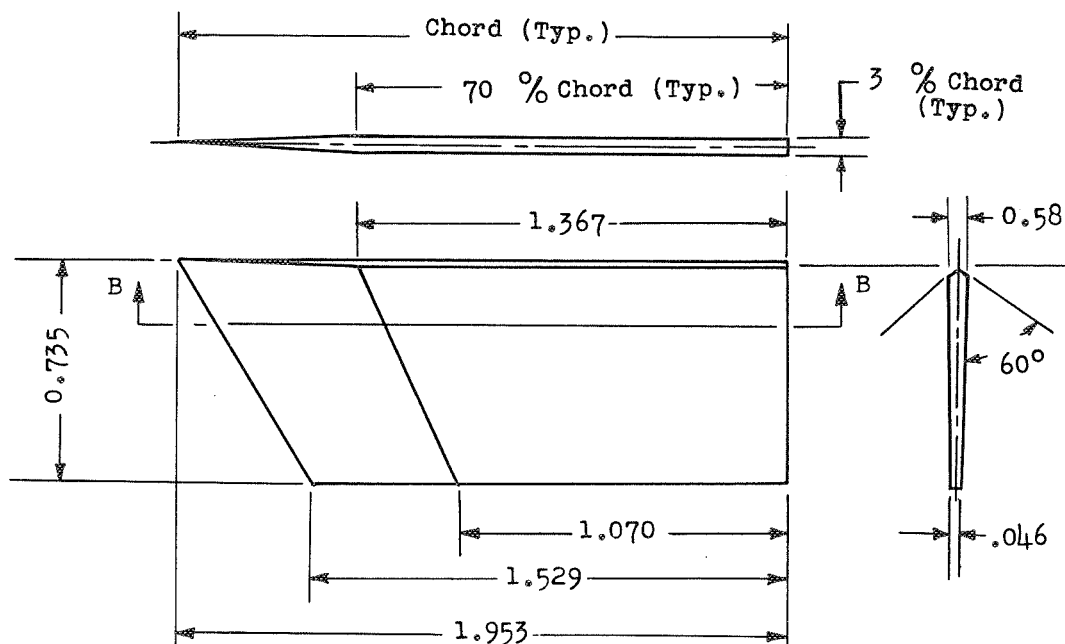


Figure 3.- TX-28 store fin configuration and dimensions. All dimensions are in inches (model scale).

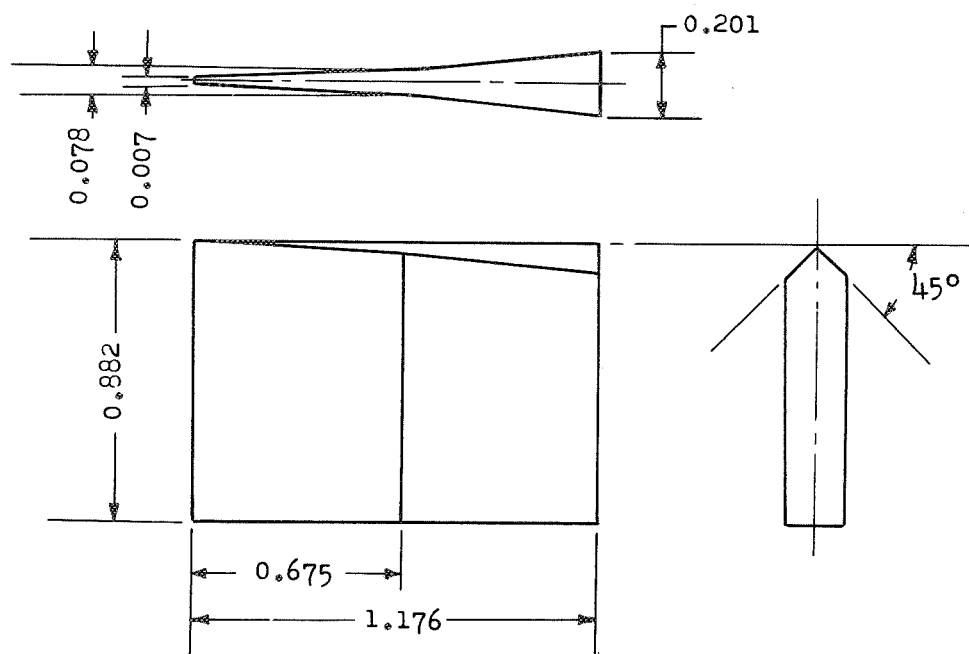
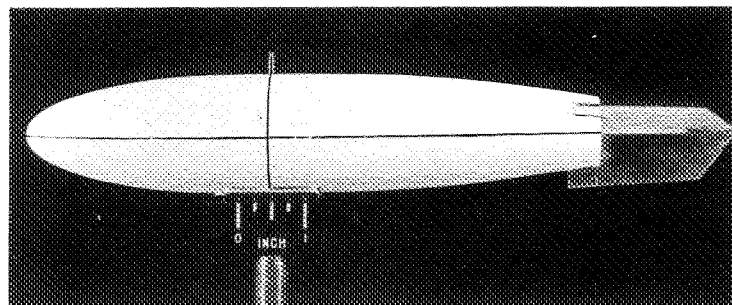
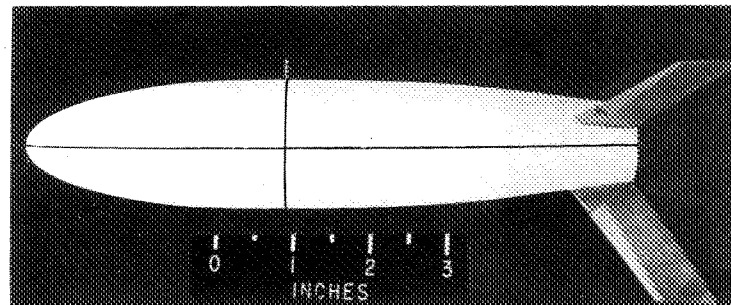


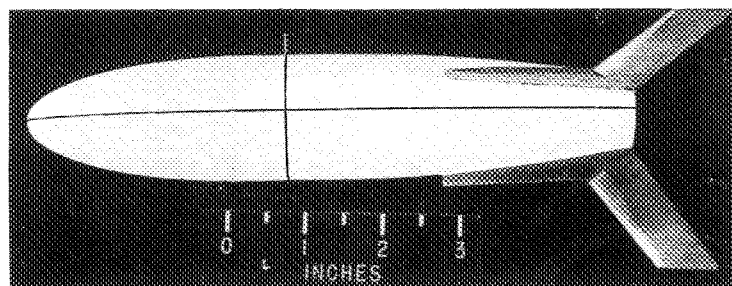
Figure 4.- Turnabout TX-28 store fin configuration and dimensions. All dimensions are in inches (model scale).



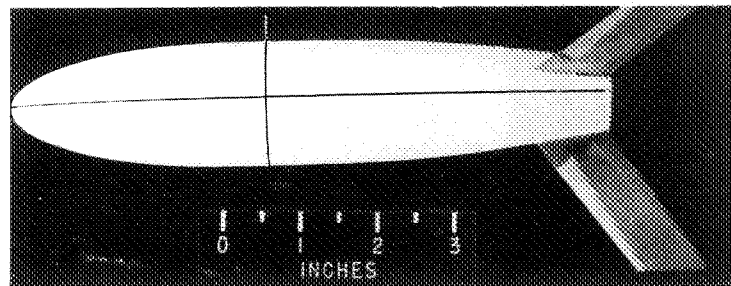
(a) Standard fins closed.



(b) Standard fins.



(c) Dorsal fins.



(d) 33-percent increase in fin area. L-95853

Figure 5.- Photographs of 1/17-scale Mk-7 store with different fin configurations.

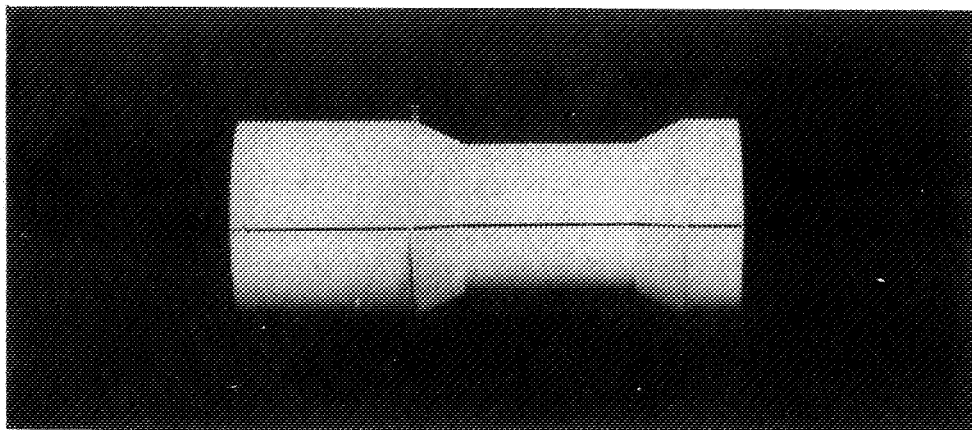


Figure 6.- Photograph of 1/17-scale bluff store. L-95850

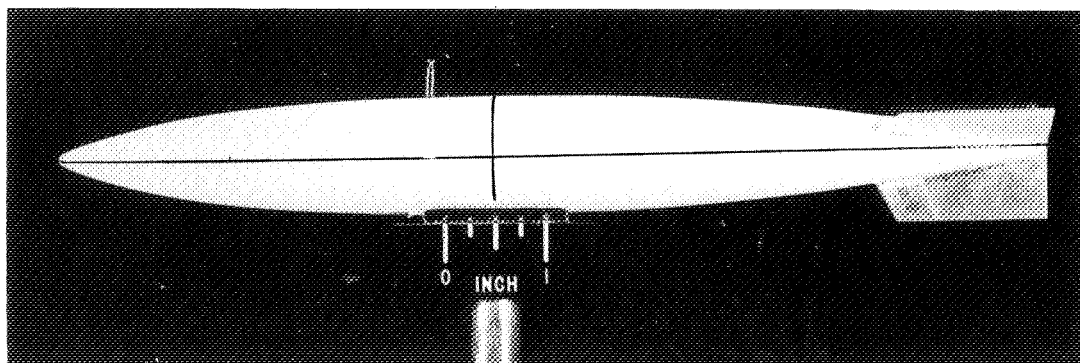


Figure 7.- Photograph of 1/17-scale TX-28 store. L-95851

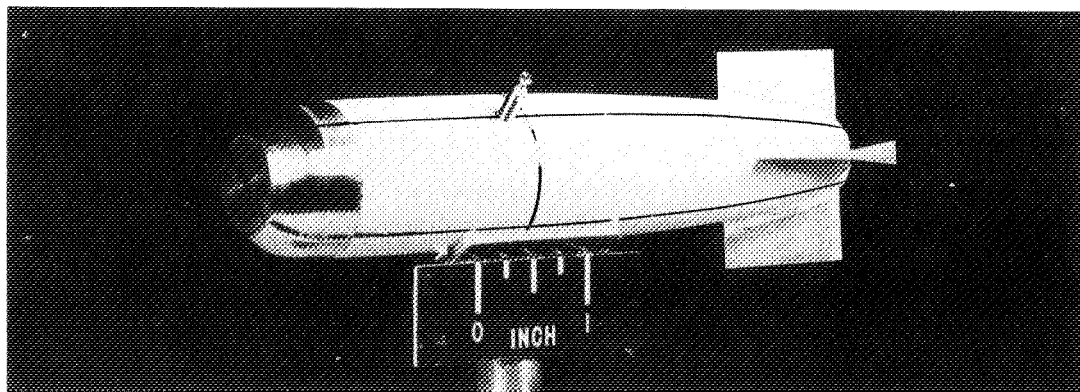
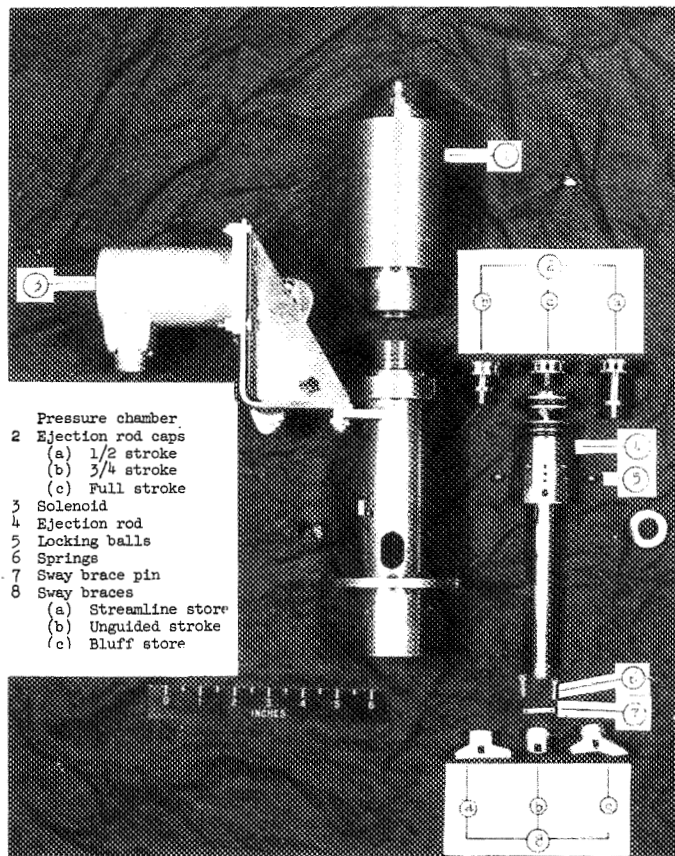


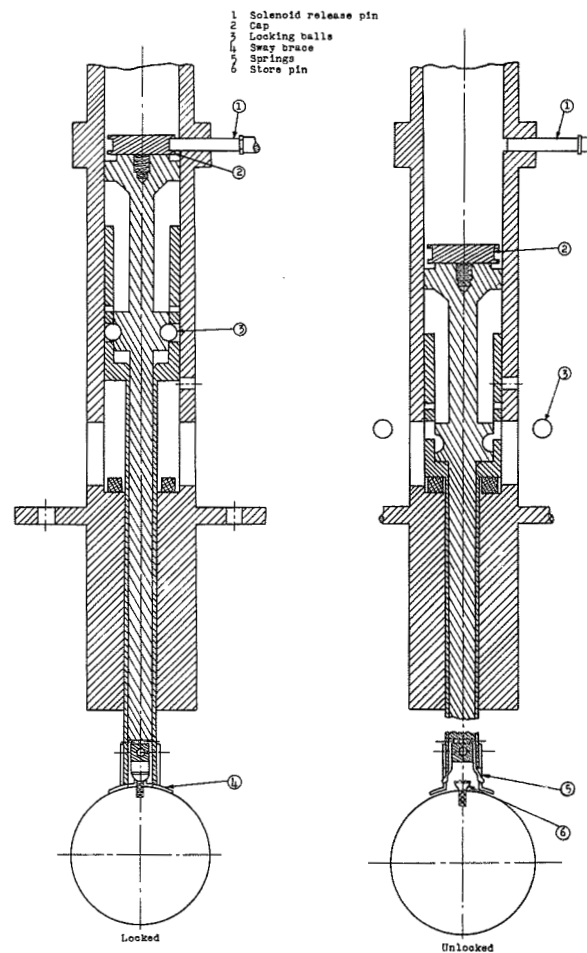
Figure 8.- Photograph of 1/17-scale turnabout TX-28 store. L-95852

CONFIDENTIAL



L-91890.1

(a) Exploded view of ejection cylinder 2 with sway braces.

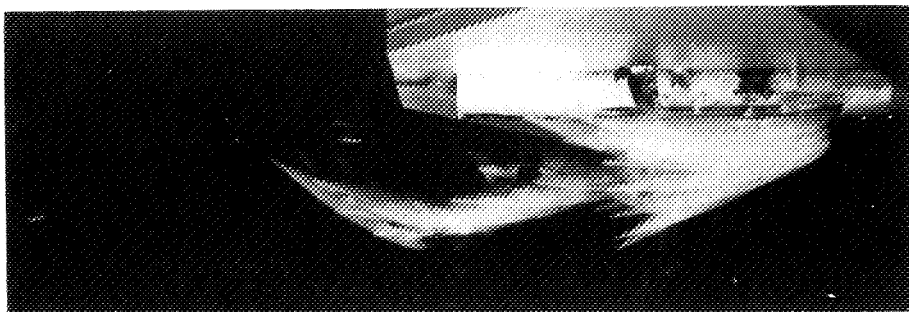


(b) Ejection-rod assembly.

Figure 9.- Ejection cylinder 2.

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(a) Test 1; magnesium fins.

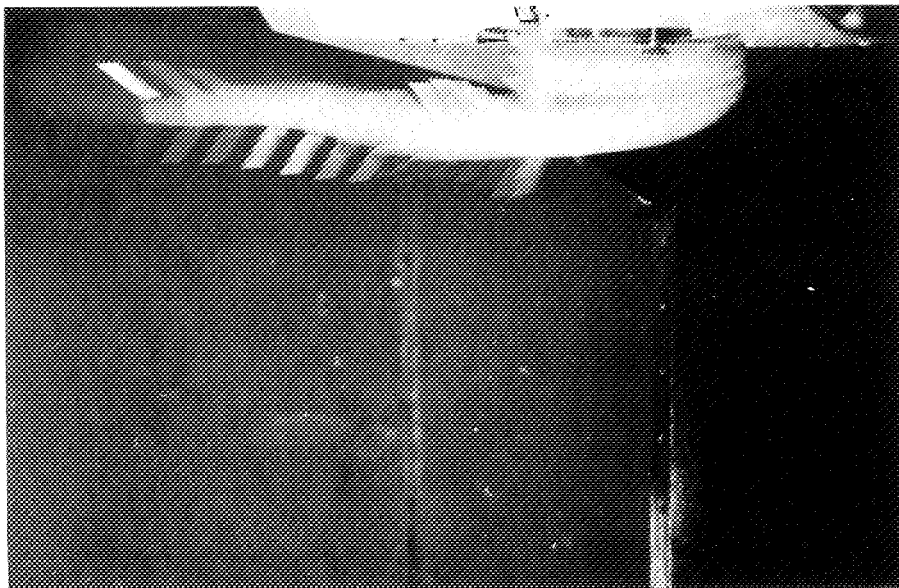


(b) Test 2; aluminum fins.

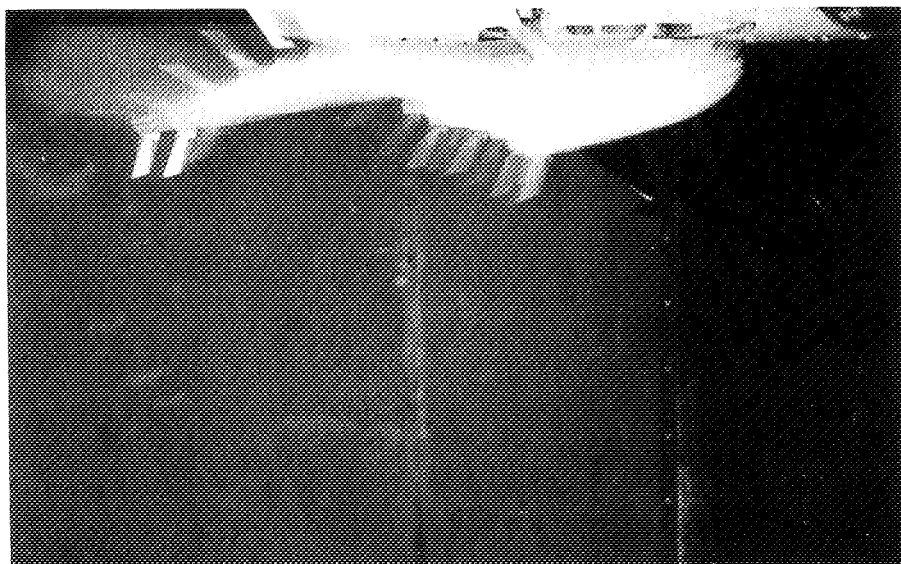


(c) Test 3; magnesium fins, with release point extended $x/d = 0.418$. L-95854

Figure 10.- Original Mk-7 store ejections at $M_0 = 1.40$, $h_p = 3,400$ feet, $\dot{z}_0 = 30$ feet per second, $\alpha_F = 0^\circ$, and $i_0 = 0^\circ$ with 0.05-inch-thick fins and ejector 1 (ref. 1).

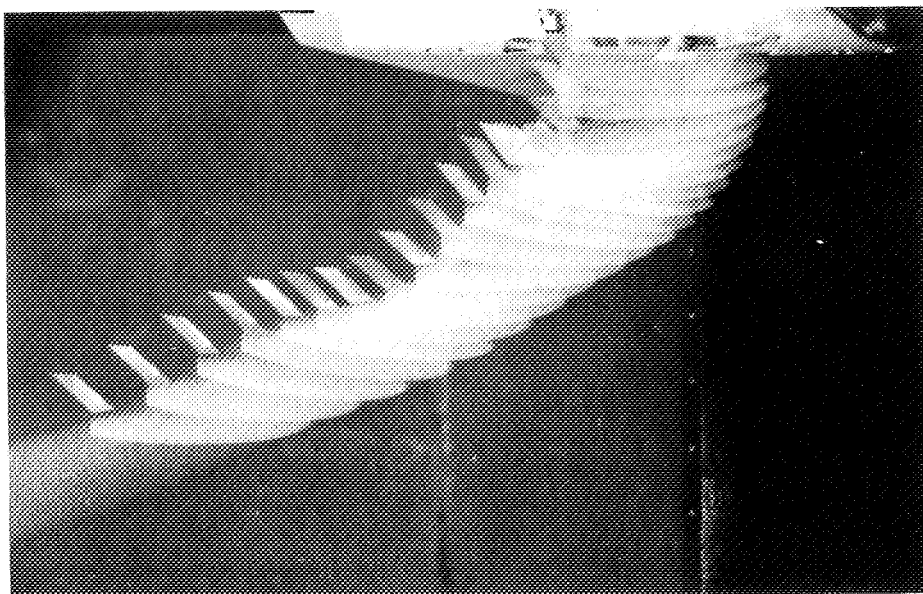


(a) Test 4; standard fins; $\dot{z}_0 = 30.0$ feet per second; $i_0 = 0^\circ$; release point extended $z/d = 0.418$.

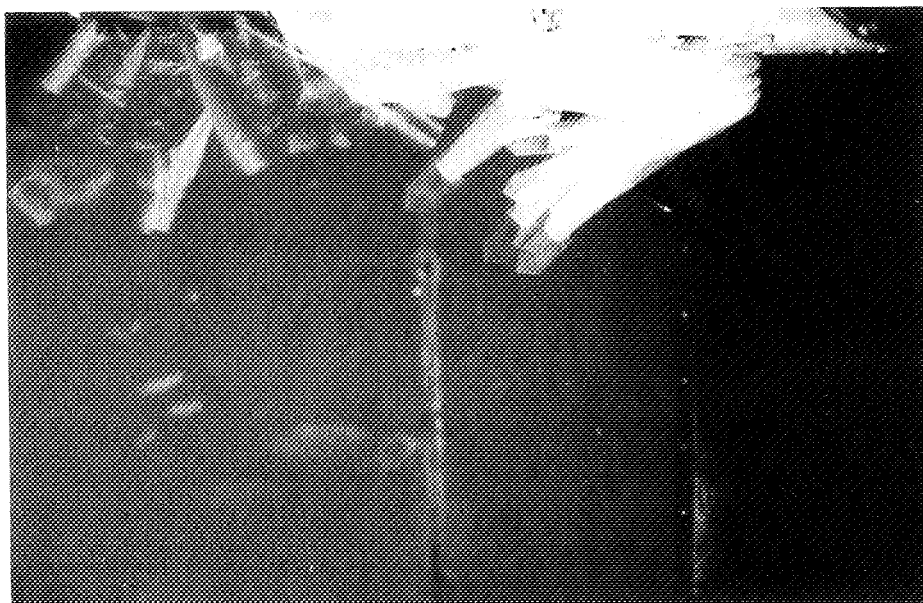


(b) Test 5; standard fins; $\dot{z}_0 = 30.0$ feet per second; $i_0 = 0^\circ$.^{L-95855}

Figure 11.- Modified Mk-7 store ejections at $M_0 = 1.39$, $h_p = 3,400$ feet, and $\alpha_F = 0^\circ$ with 0.10-inch-thick magnesium fins.

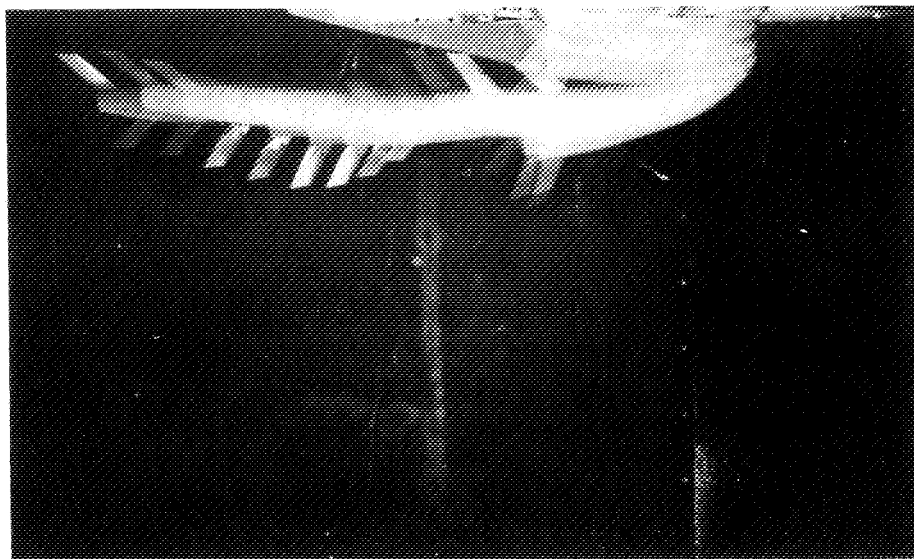


(c) Test 6; standard fins; $\dot{z}_0 = 45.0$ feet per second; $i_0 = 0^\circ$.

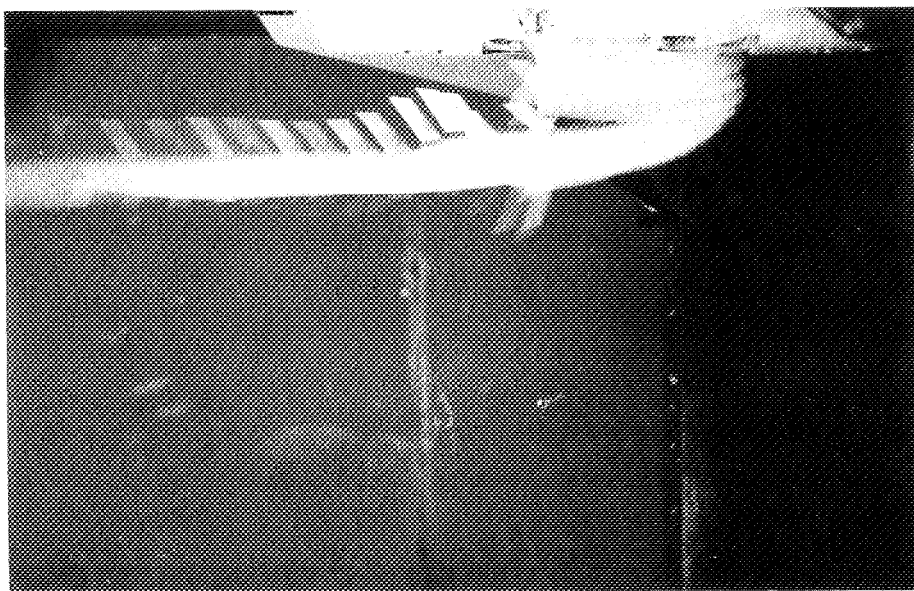


(d) Test 7; fins folded; $\dot{z}_0 = 30.0$ feet per second; $i_0 = -4^\circ$. L-95856

Figure 11.- Continued.

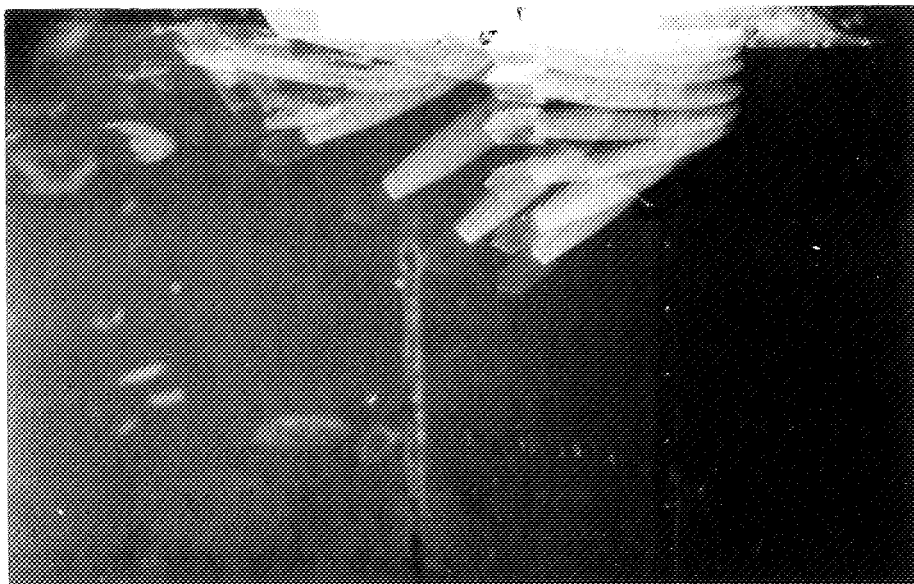


(e) Test 8; standard fins; $\dot{z}_0 = 30.0$ feet per second; $i_0 = -4^\circ$.

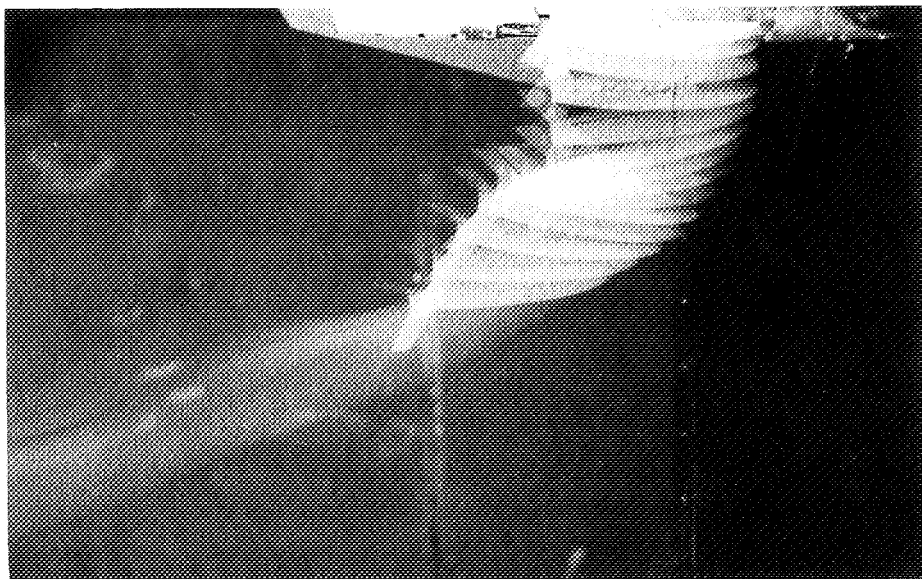


(f) Test 9; repeatability of test 8. L-95857

Figure 11.- Continued.

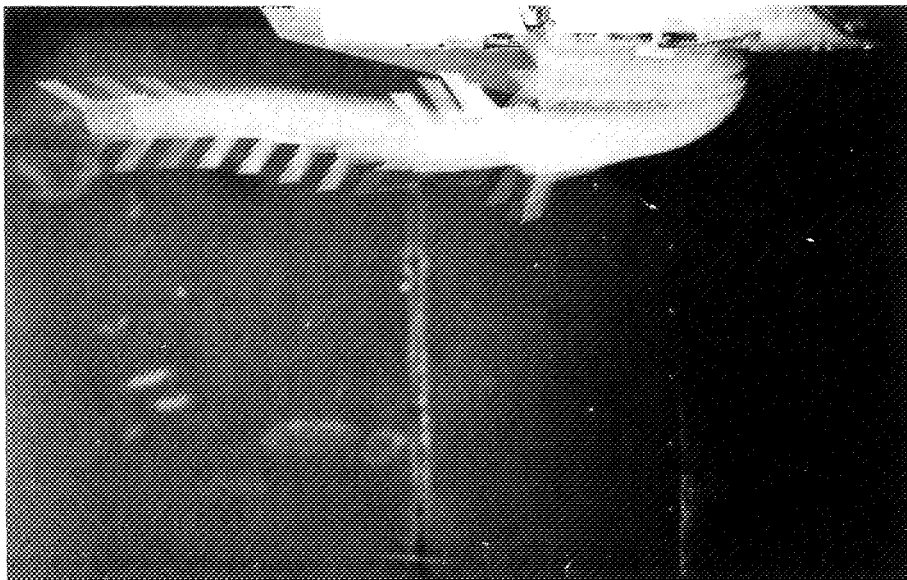


(g) Test 10; fins folded; $\dot{z}_0 = 45.0$ feet per second; $i_0 = -4^\circ$.

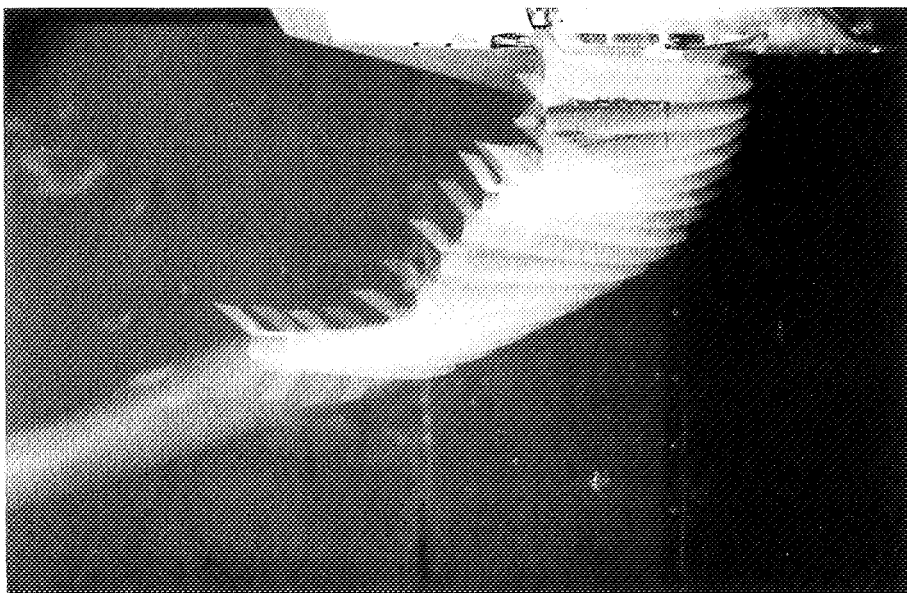


(h) Test 11; standard fins; $\dot{z}_0 = 45.0$ feet per second; $i_0 = -4^\circ$.
L-95858

Figure 11.- Continued.

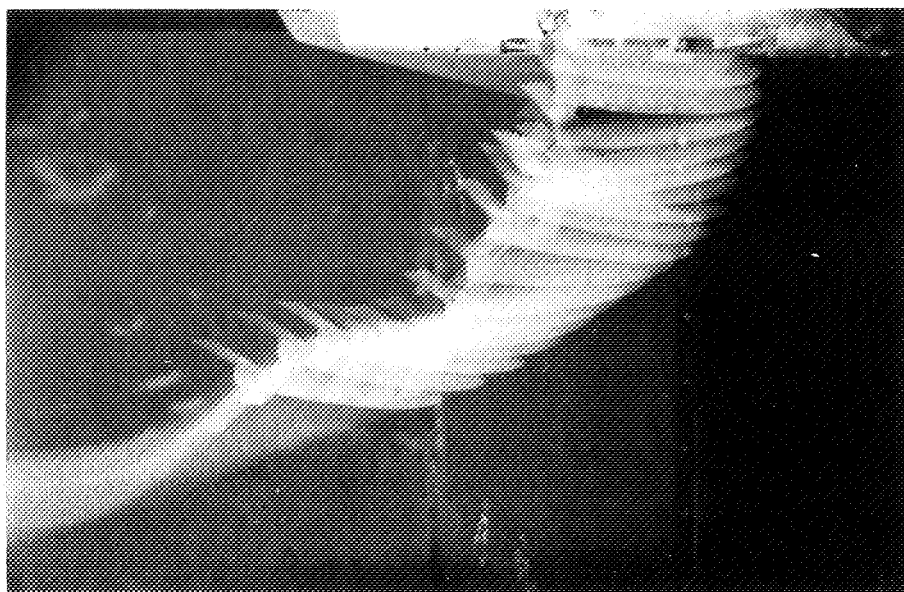


(i) Test 12; dorsal fins; $\dot{z}_0 = 30.0$ feet per second; $i_0 = -4^\circ$.

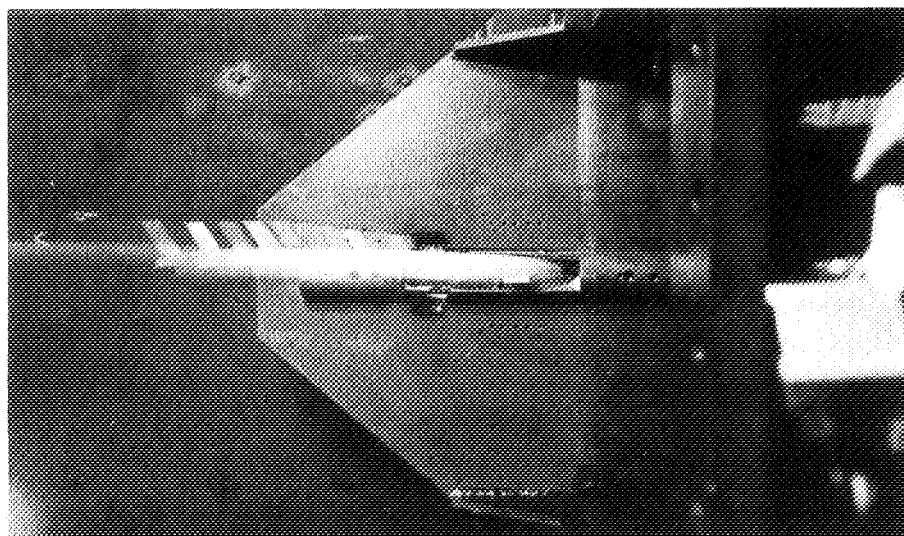


(j) Test 13; dorsal fins; $\dot{z}_0 = 45.0$ feet per second; $i_0 = -4^\circ$. L-95859

Figure 11.- Continued.



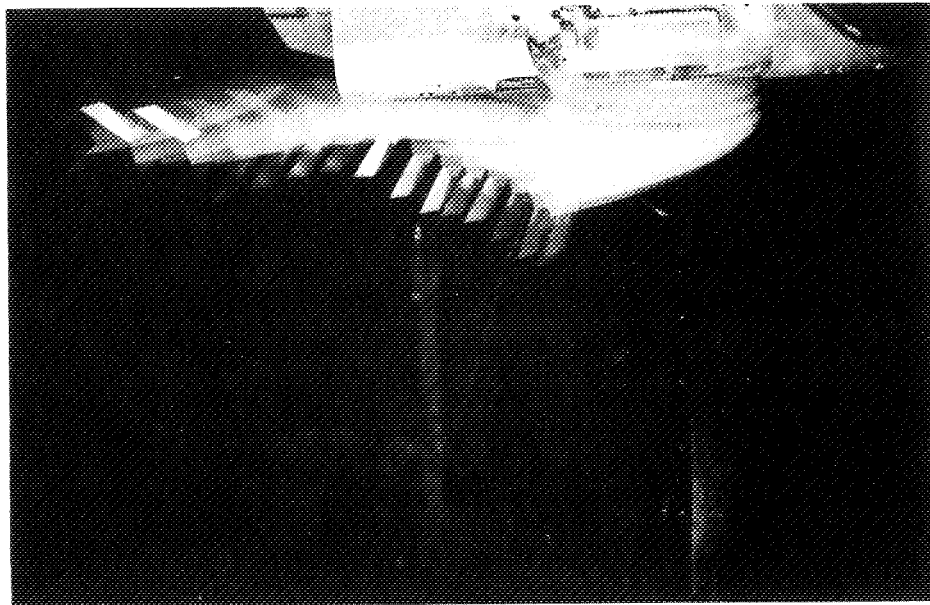
Side View



Bottom view

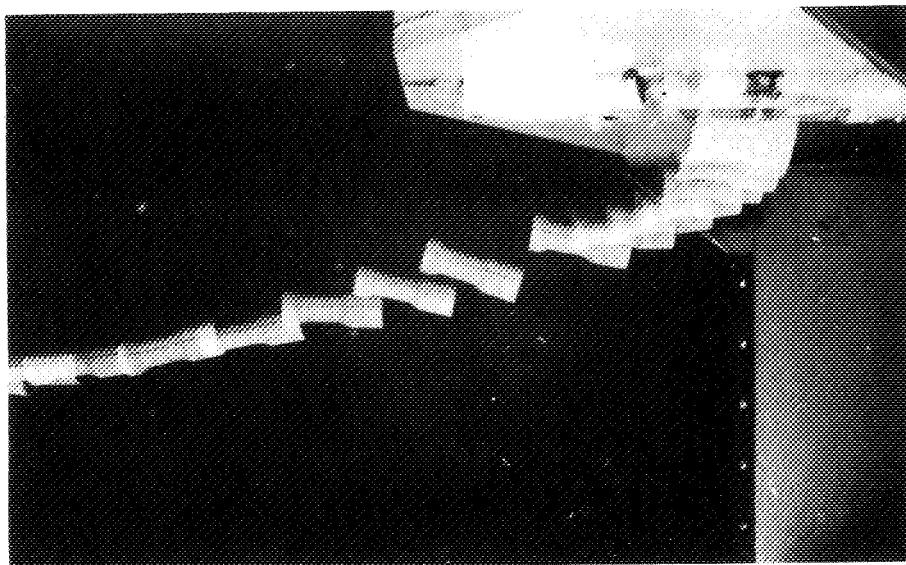
(k) Test 14; 33-percent increase of fin area; $\dot{z}_0 = 45$ feet per second;
and $i_0 = -40^\circ$. L-95860

Figure 11.- Continued.

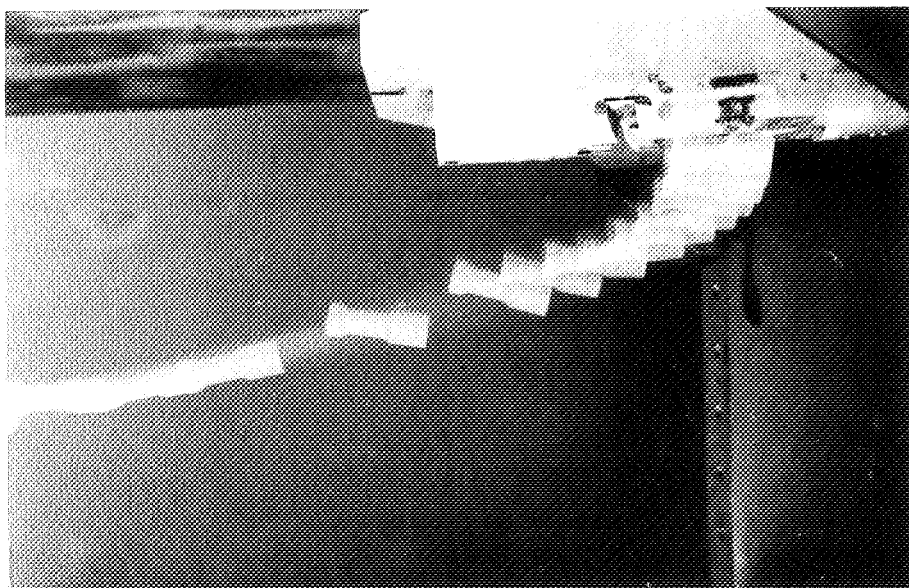


(7) Test 15; standard fins; $\alpha_F = 30^\circ$; $\dot{z}_O = 30$ feet per second; and $i_O = -40^\circ$. L-95861

Figure 11.- Concluded.

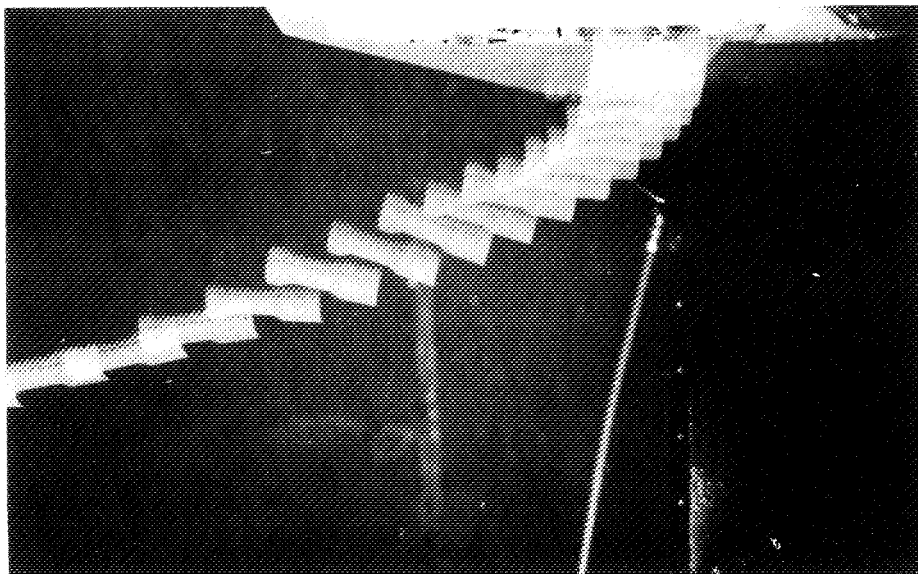


(a) Test 16; $\dot{z}_0 = 24.5$ feet per second; $\alpha_f = 0^\circ$; full guided stroke.

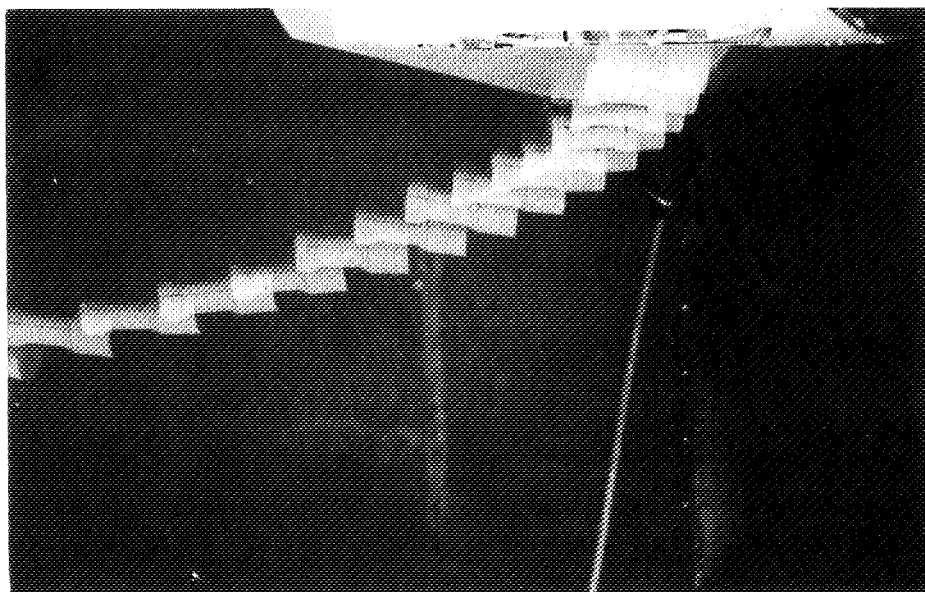


(b) Test 17; $\dot{z}_0 = 25.0$ feet per second; full guided stroke at $\alpha_f = 3^\circ$.

Figure 12.- Bluff-store ejections at $M_0 = 1.39$. $h_p = 3,400$ feet; $i_0 = 0^\circ$.



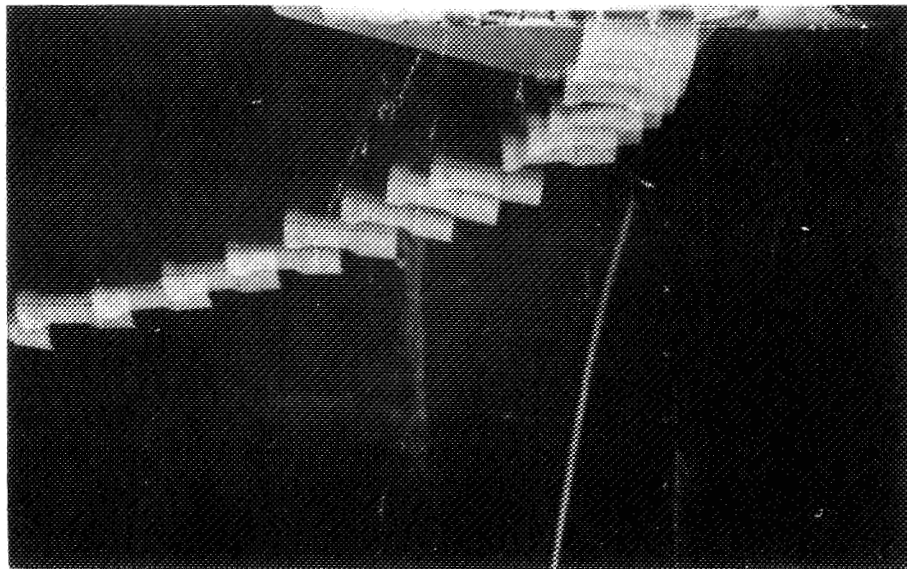
(c) Test 18; $\dot{z}_0 = 33.5$ feet per second; $\alpha_f = 0^\circ$; full guided stroke.



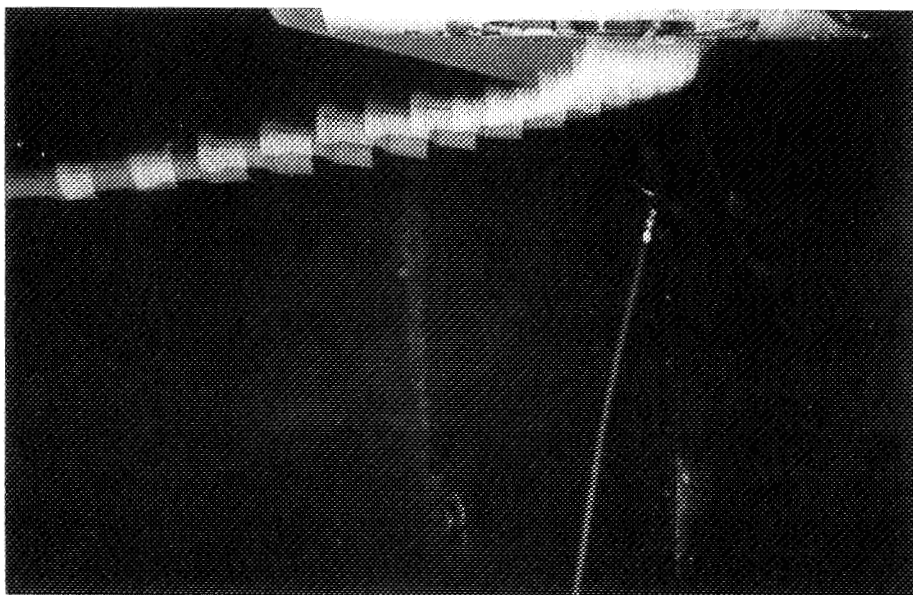
(d) Test 19; $\dot{z}_0 = 34.5$ feet per second; $\alpha_f = 0^\circ$; three-quarter guided stroke.

L-95863

Figure 12.- Continued.

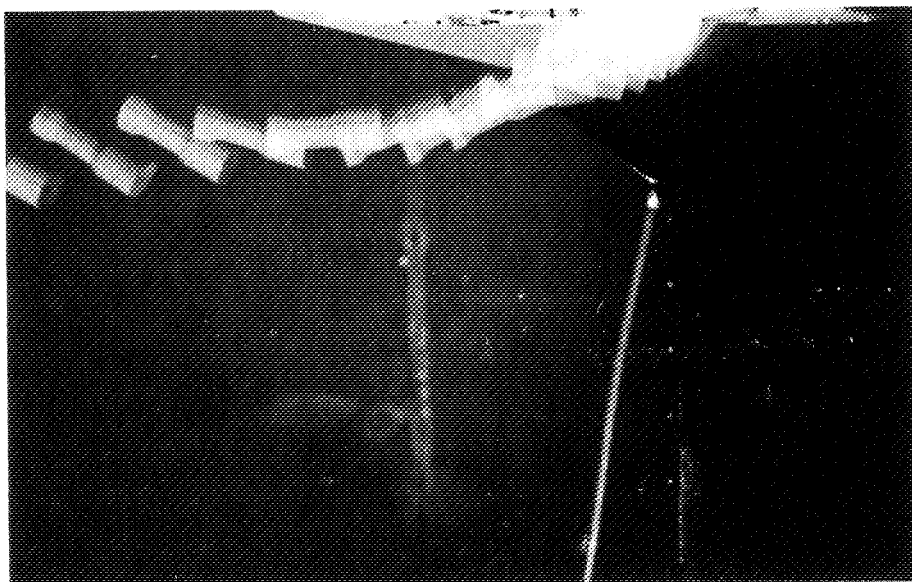


(e) Test 20; $\dot{z}_0 = 34.5$ feet per second; $\alpha_f = 0^\circ$; full unguided stroke.



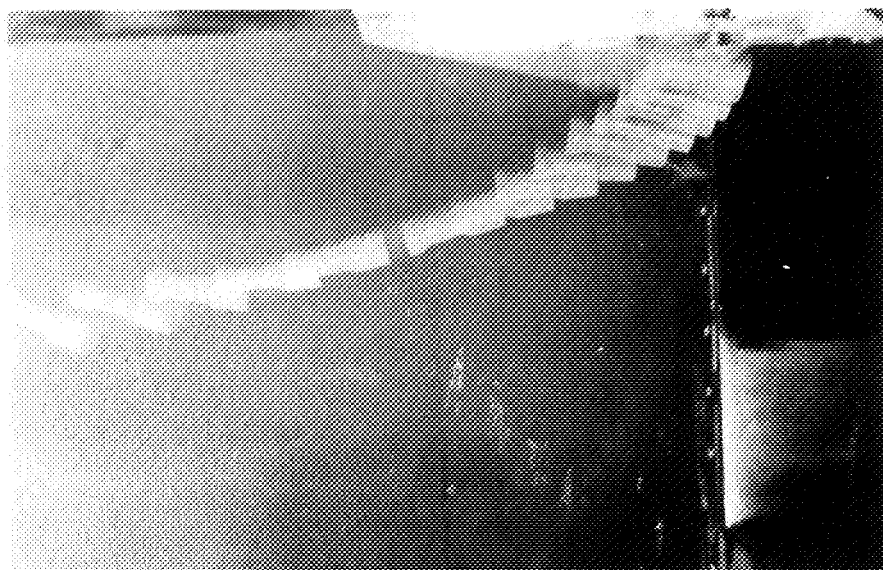
(f) Test 21; $\dot{z}_0 = 12.5$ feet per second; $\alpha_f = 0^\circ$; full guided stroke. L-95864

Figure 12.- Continued.

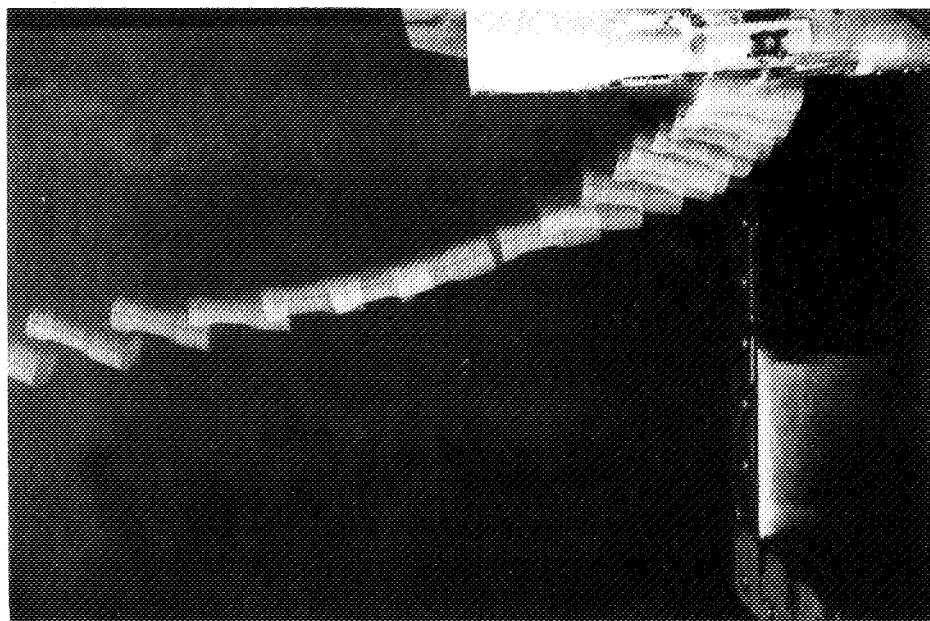


(g) Test 22; $\dot{z}_0 = 12.5$ feet per second; $\alpha_f = 0^\circ$; one-half guided stroke. L-95865

Figure 12.- Concluded.

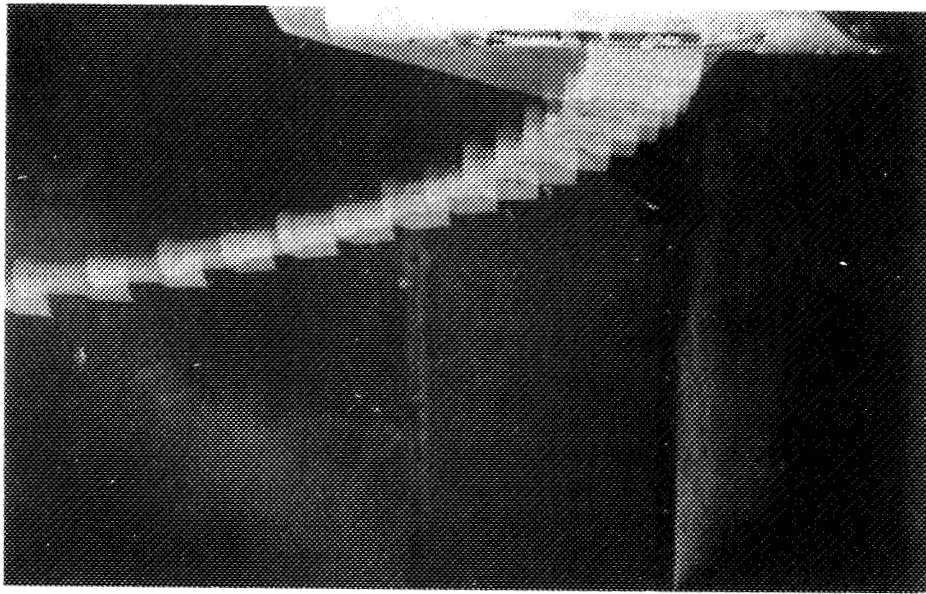


(a) Test 23; $\dot{z}_0 = 26.5$ feet per second; $\alpha_f = 0^\circ$; full guided stroke.

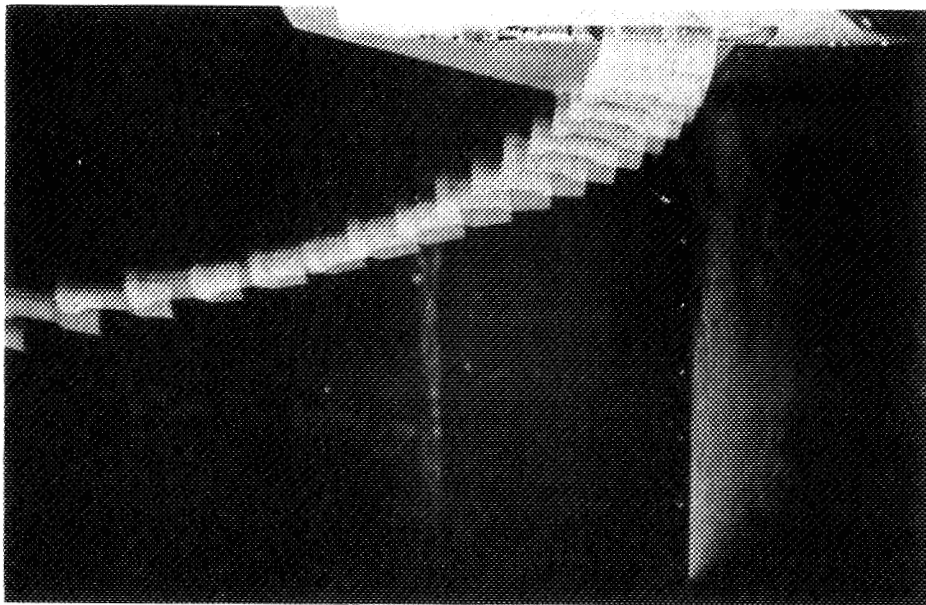


(b) Test 24; $\dot{z}_0 = 26.0$ feet per second; full guided stroke; $\alpha_f = 3^\circ$. L-95866

Figure 13.- Bluff-store ejections at $M_0 = 1.98$. $h_p = 29,000$ feet; $i_0 = 0^\circ$.



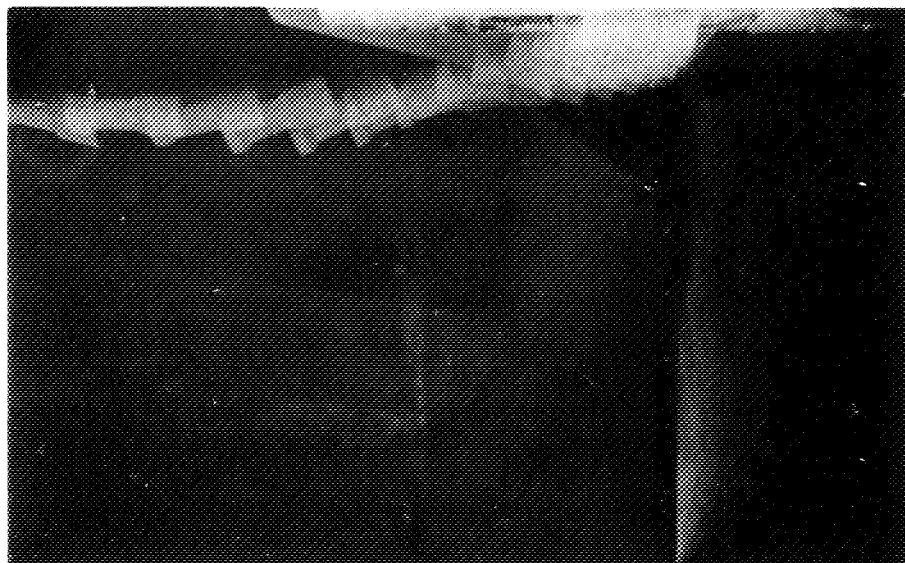
(c) Test 25; $\dot{z}_0 = 28.0$ feet per second; $\alpha_f = 0^\circ$; three-quarter guided stroke.



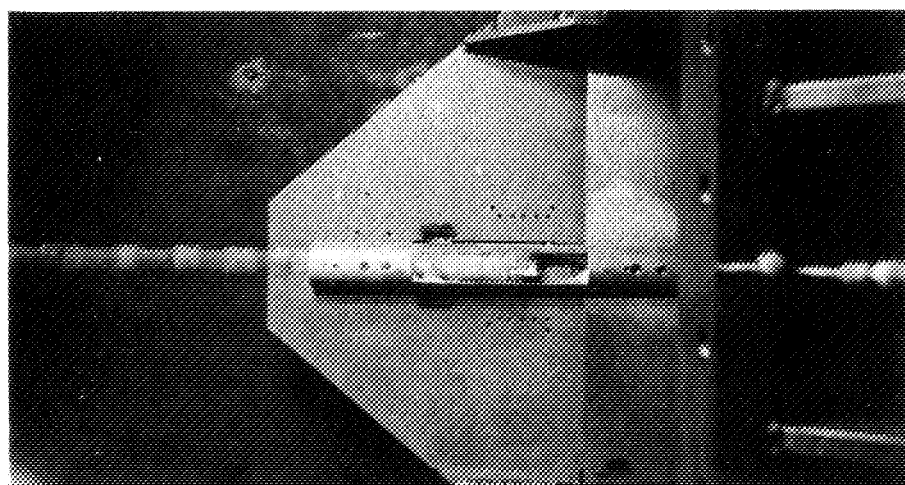
(d) Test 26; $\dot{z}_0 = 23.5$ feet per second; $\alpha_f = 0^\circ$; full unguided stroke.

L-95867

Figure 13.- Continued.



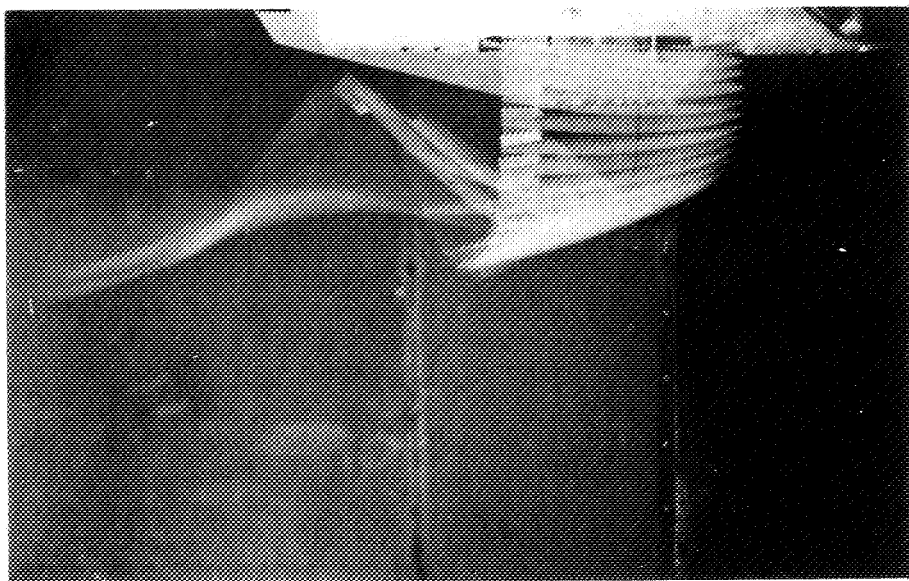
Side View



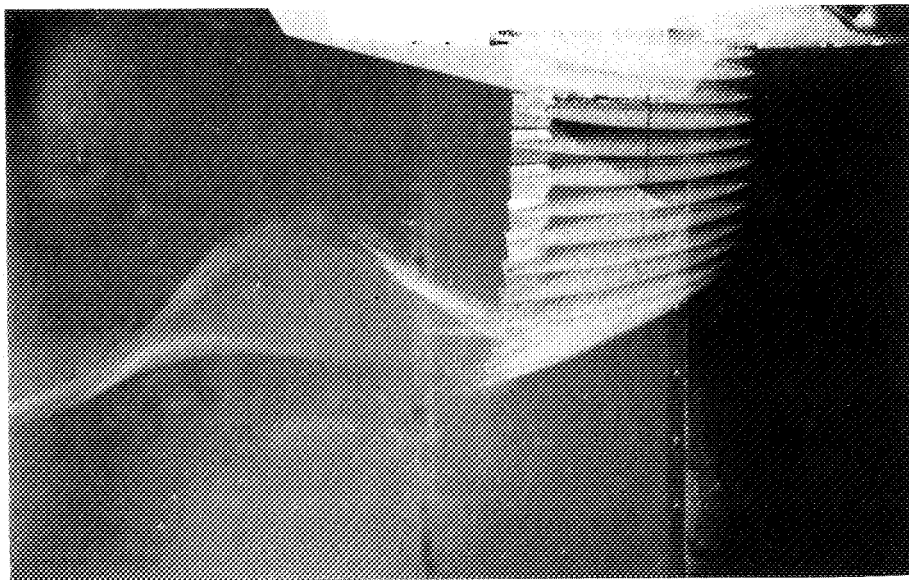
Bottom View

(e) Test 27; $\dot{z}_0 = 12.5$ feet per second; $\alpha_F = 0^\circ$; one-half guided stroke. L-95868

Figure 13.- Concluded.

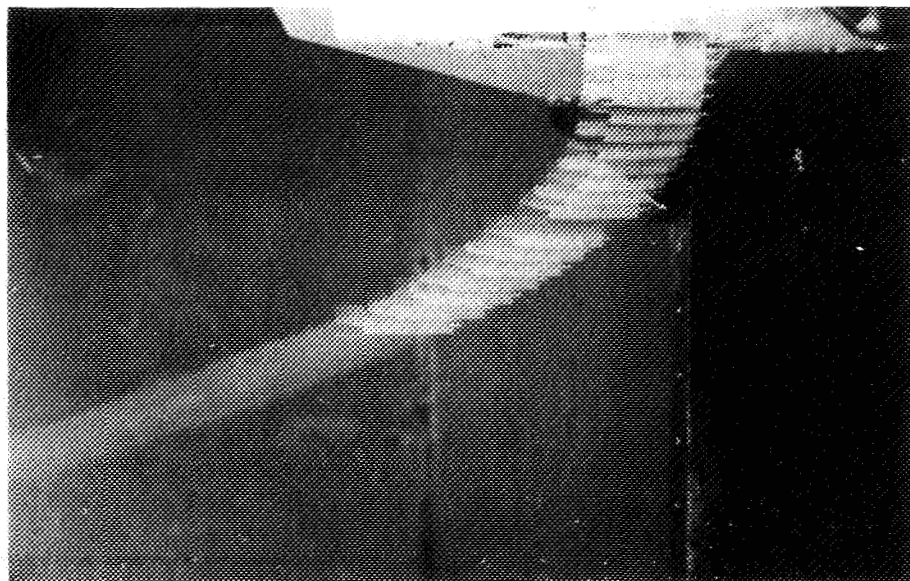


(a) Test 28; $\dot{z}_0 = 34.0$ feet per second.

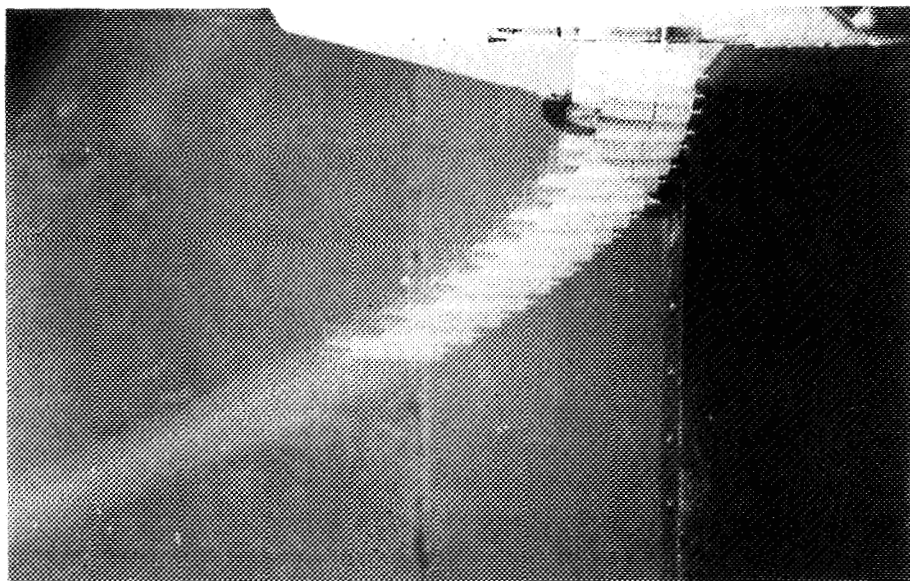


(b) Test 29; $\dot{z}_0 = 46.0$ feet per second.

Figure 14.- Shape TX-28 store ejections at $M_0 = 1.39$. $h_p = 3,400$ feet;
 $\alpha_f = 0^\circ$; and $i_0 = -4^\circ$. L-95869



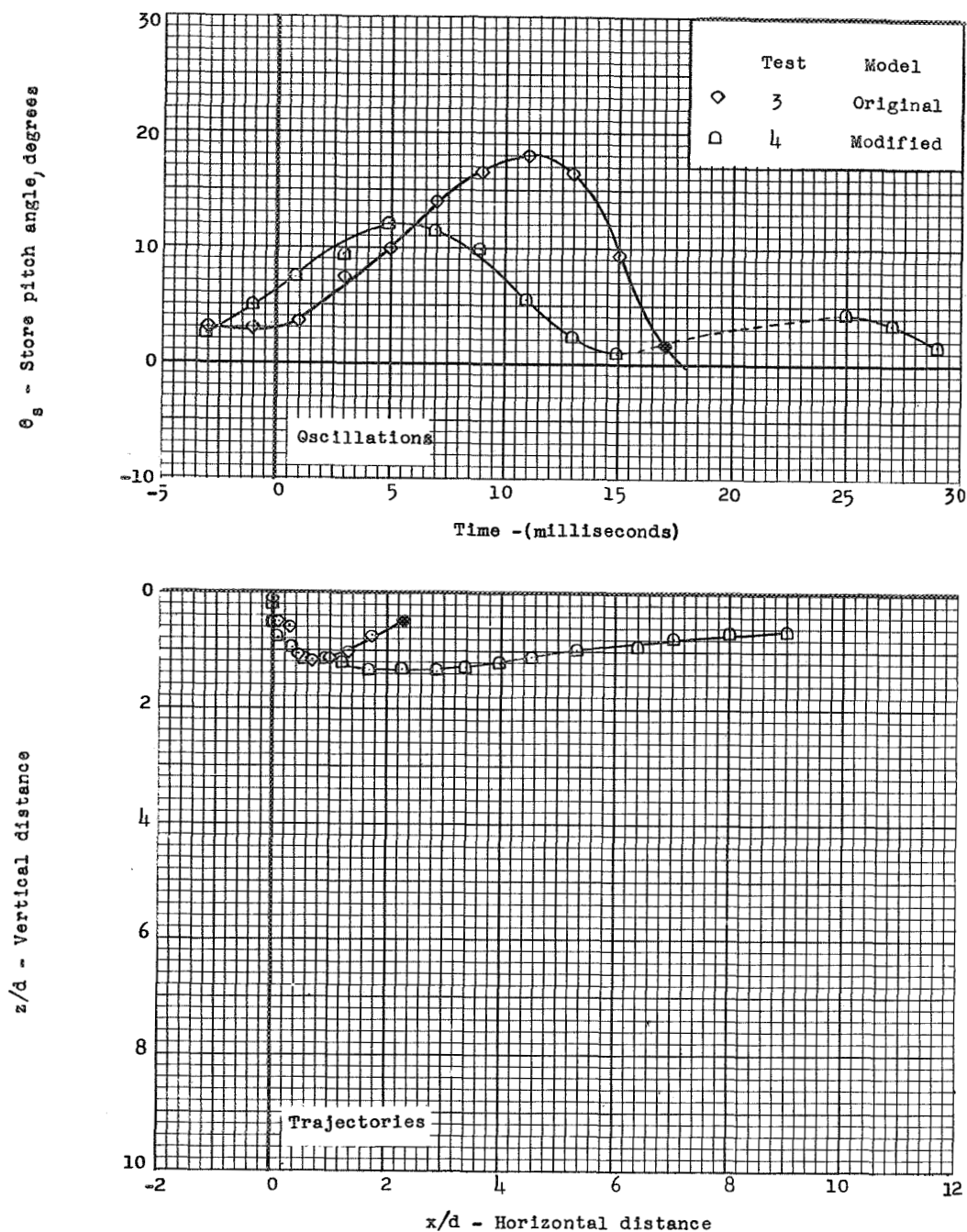
(a) Test 30; $i_0 = 0^\circ$.



(b) Test 31; $i_0 = -4^\circ$.

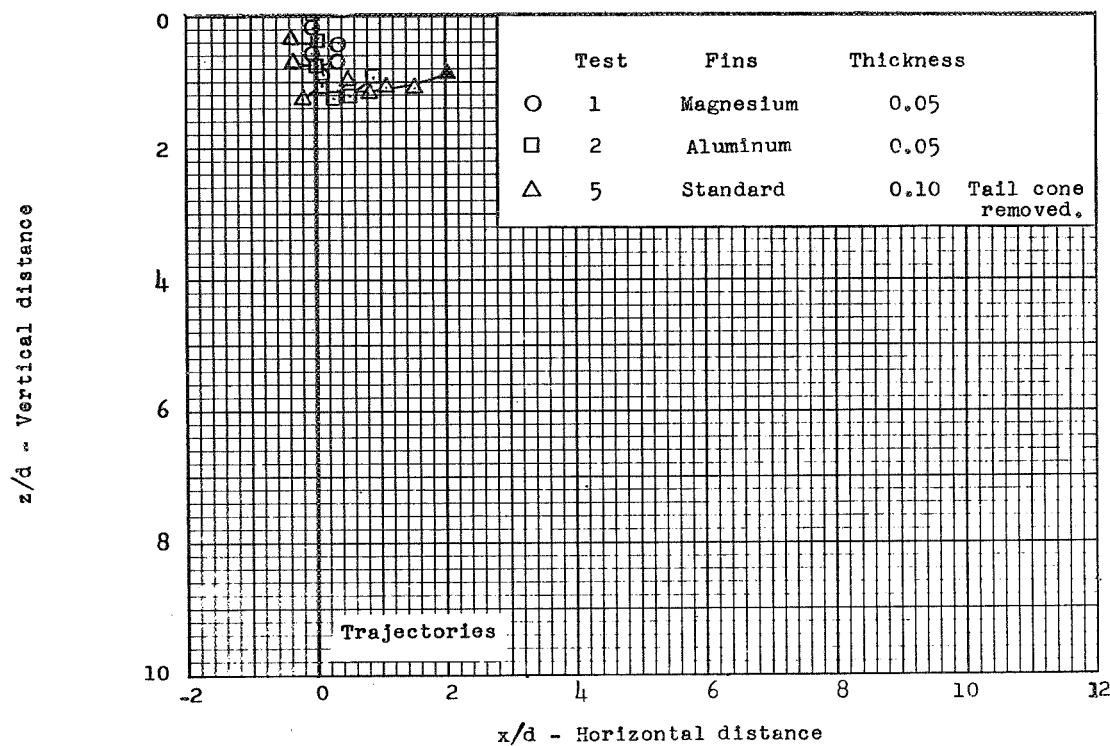
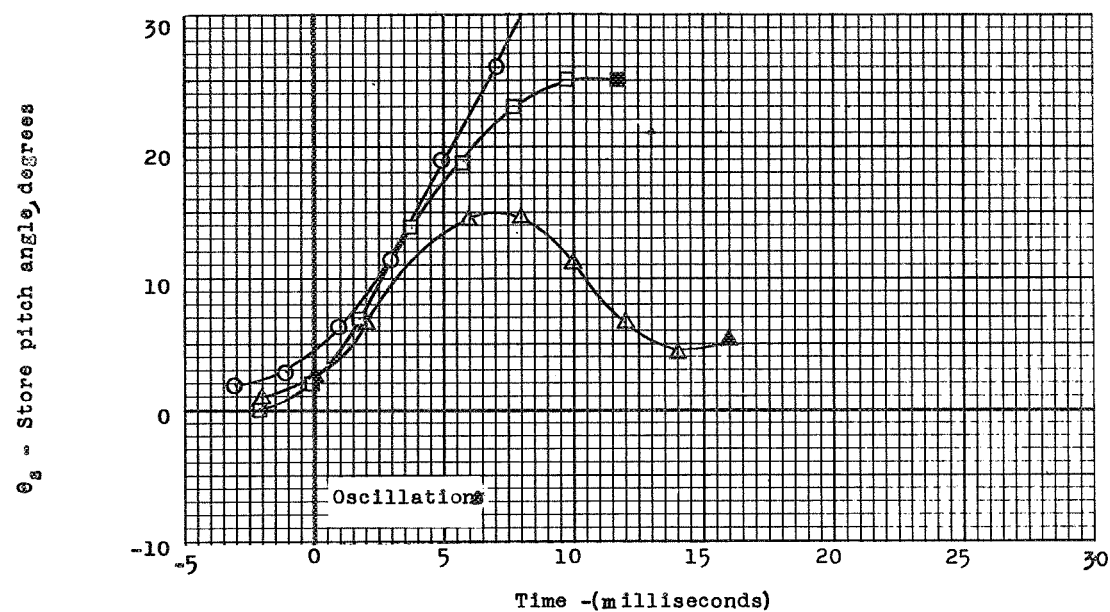
L-95870

Figure 15.- Turnabout TX-28 store ejections at $M_0 = 1.39$.
 $h_p = 3,400$ feet; $\alpha_f = 0^\circ$; and $\dot{z}_0 = 27.5$ feet per second.



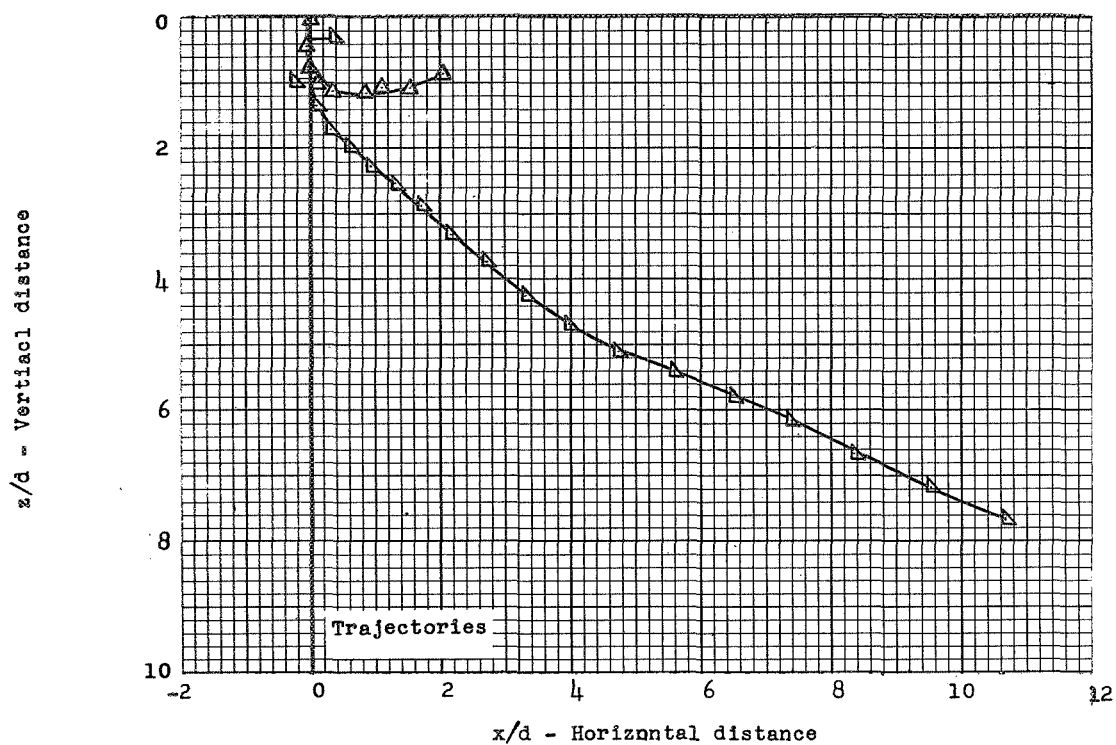
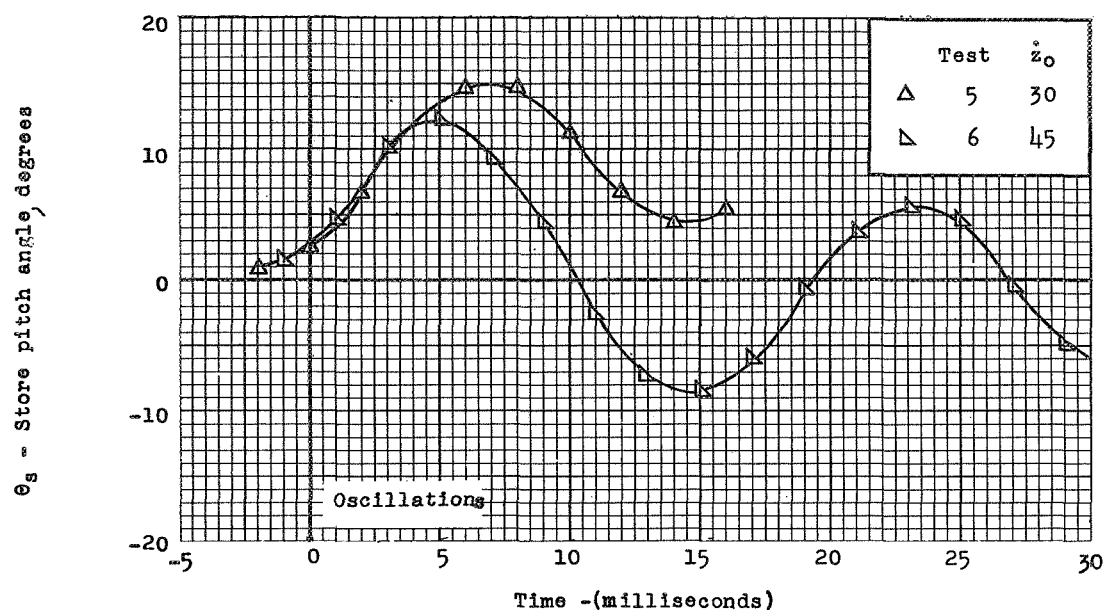
(a) Comparison of modified-store and original-store (ref. 1) ejection with ejector 1 extended $x/d = 0.418$ at $\dot{z}_0 = 30$ feet per second.

Figure 16.- Mk-7 store oscillations and trajectories at $M = 1.39$.
 $h_p = 3,400$ feet; and $\alpha_F = 0^\circ$.



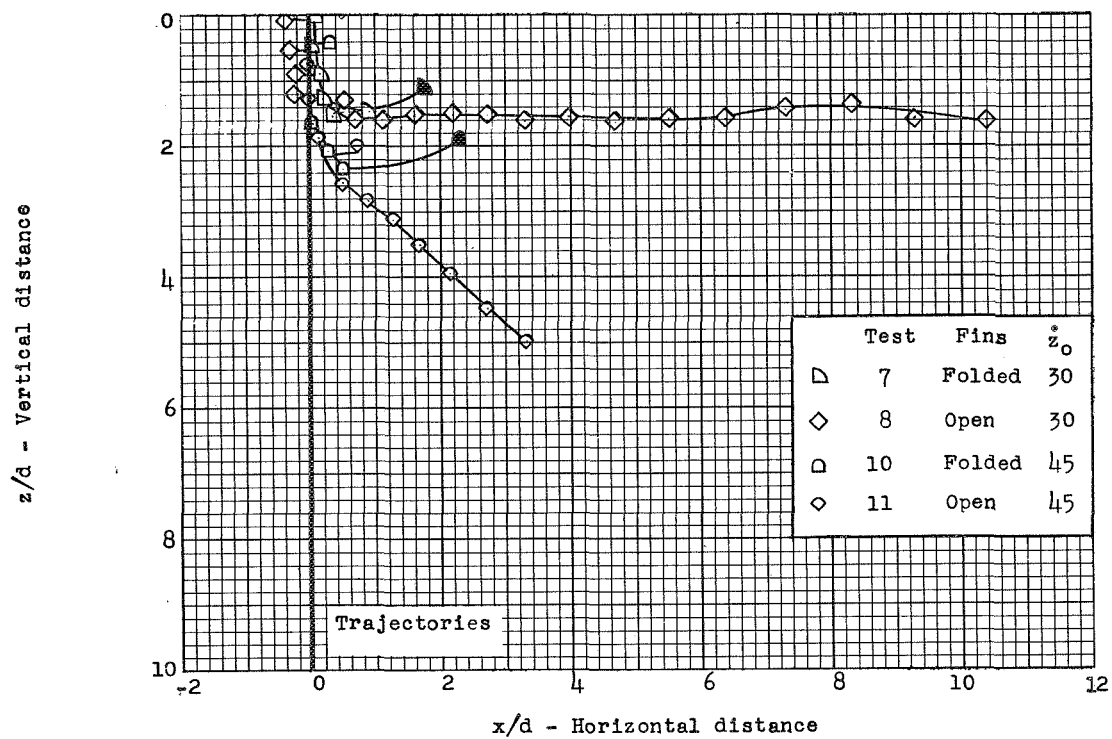
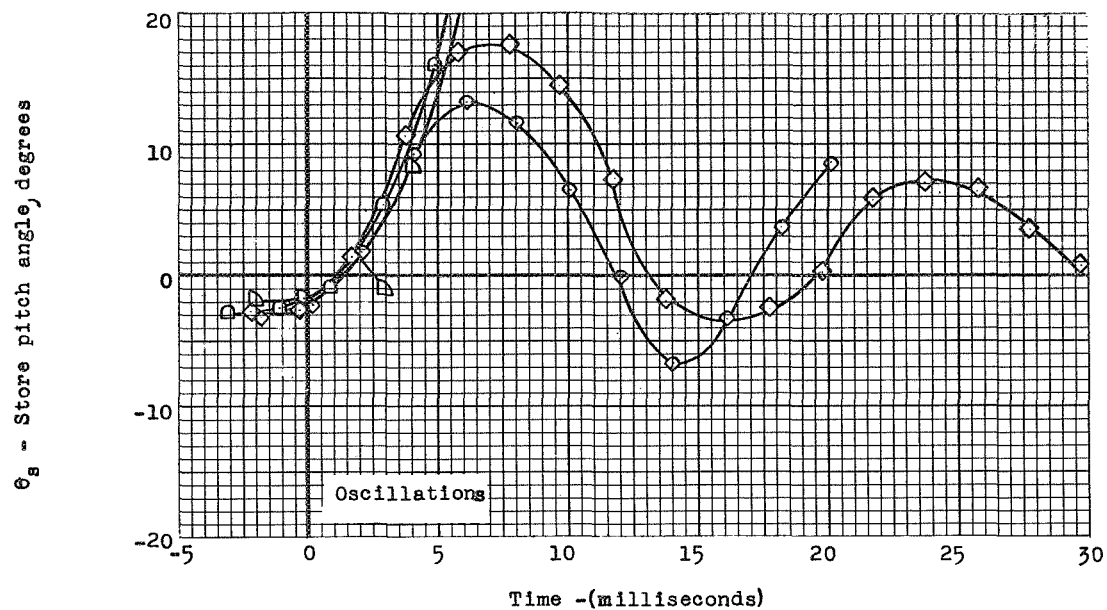
(b) Comparison of fins and body changes at $\dot{z}_0 = 30$ feet per second.

Figure 16.- Continued.



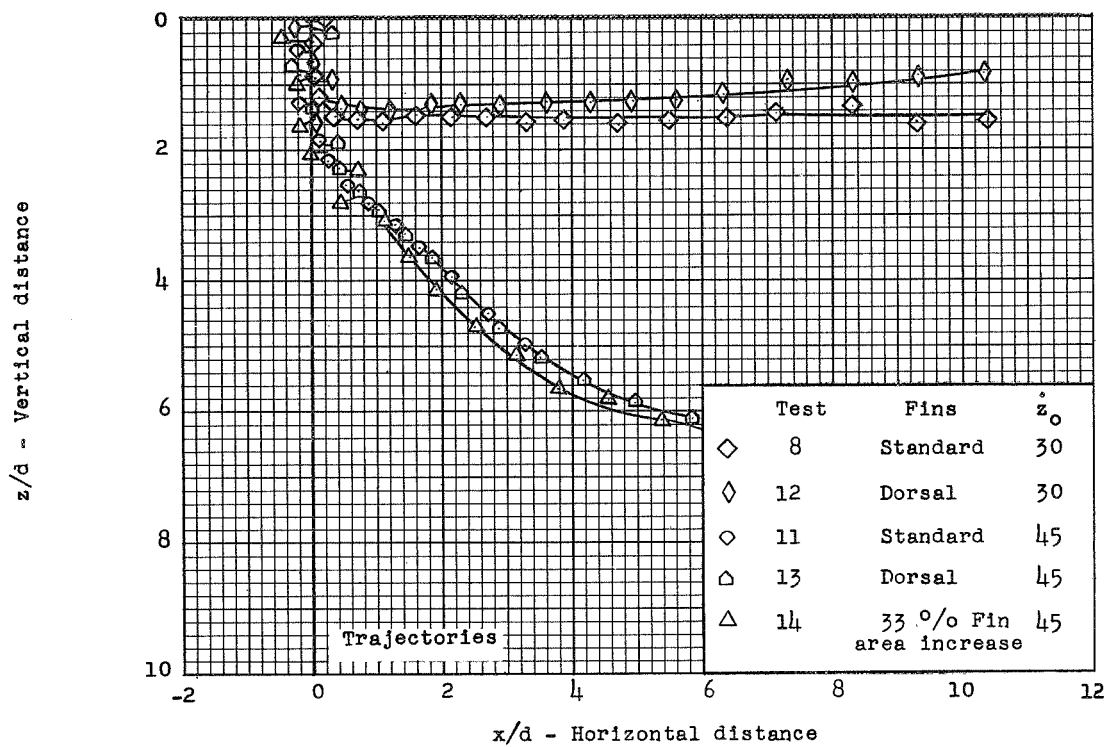
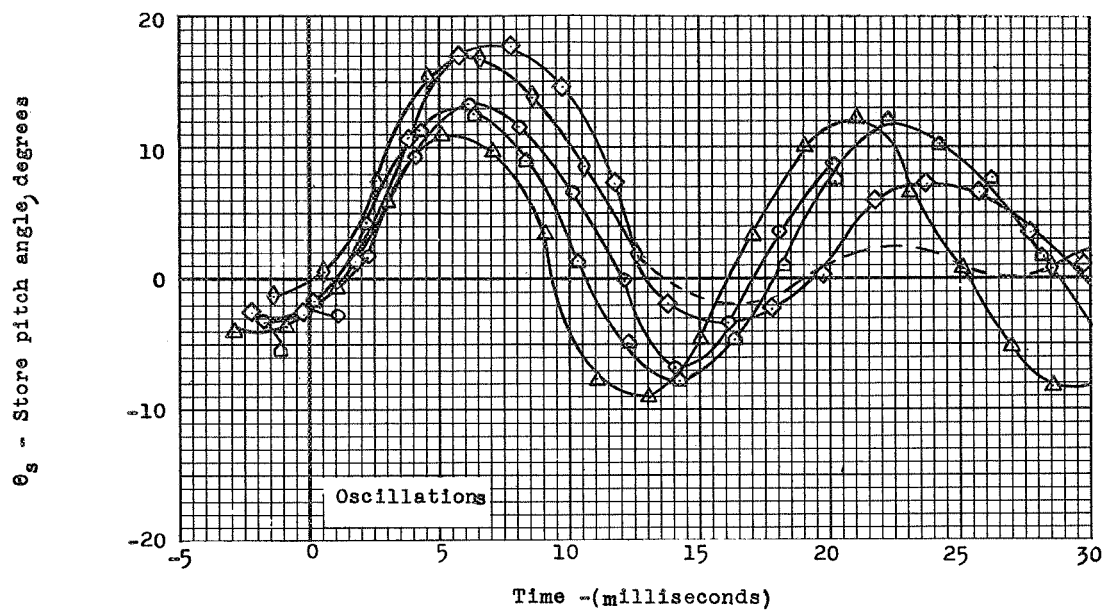
(c) Comparison of ejection velocity change with modified store.

Figure 16.- Continued.



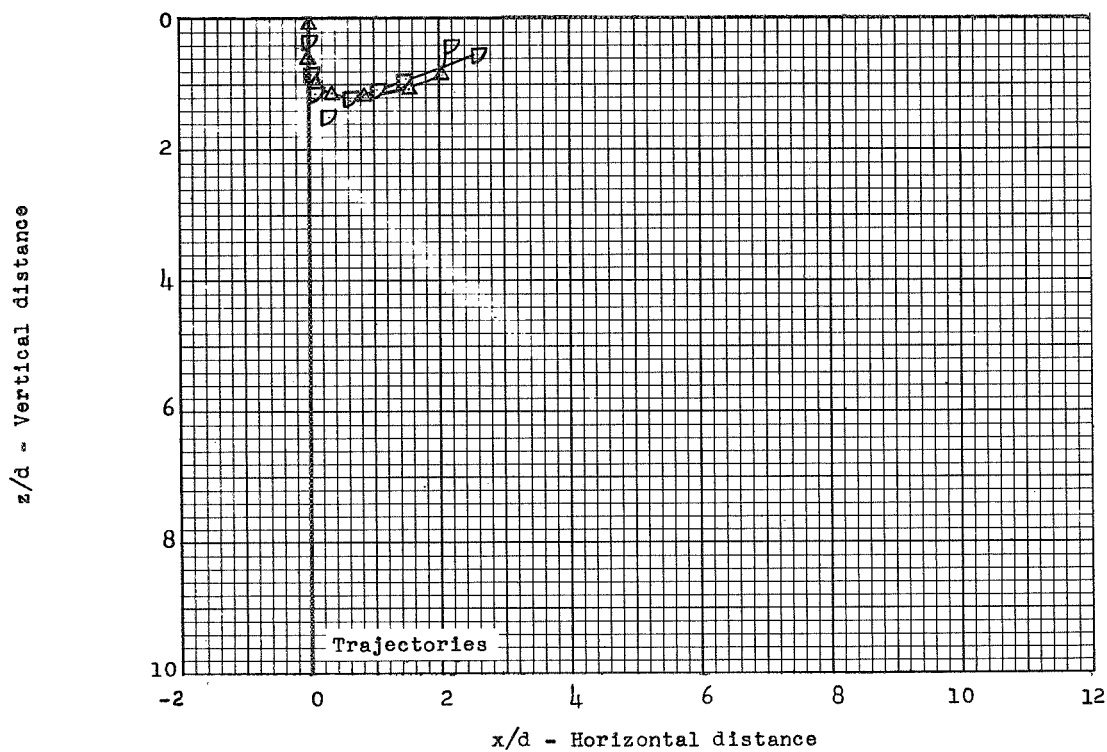
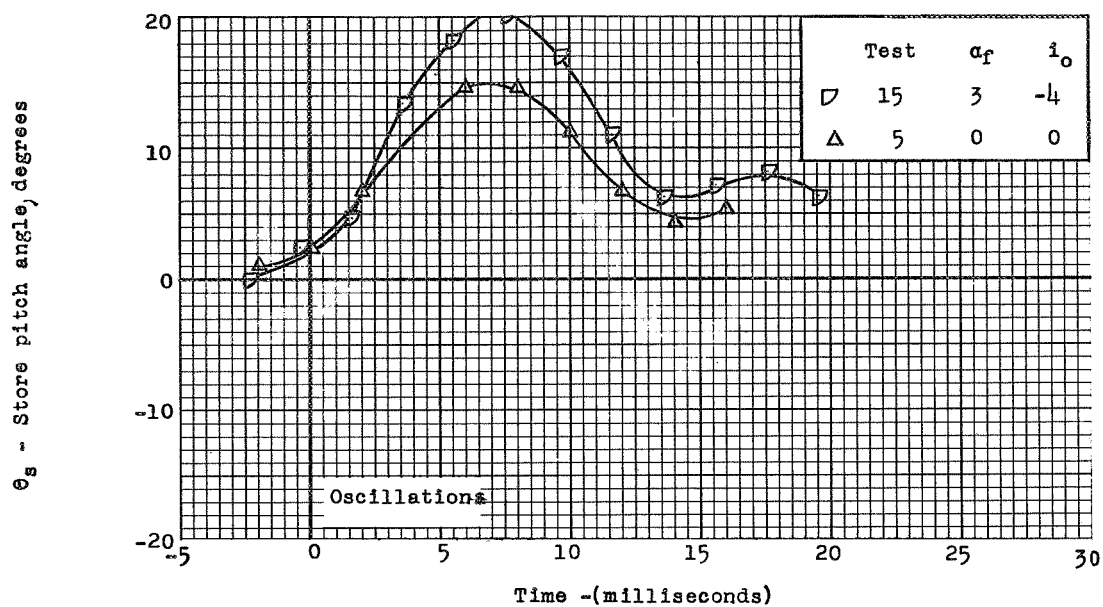
(d) Ejections at $i_0 = -4^\circ$ with standard fins open and closed and ejection velocity changes.

Figure 16.- Continued.



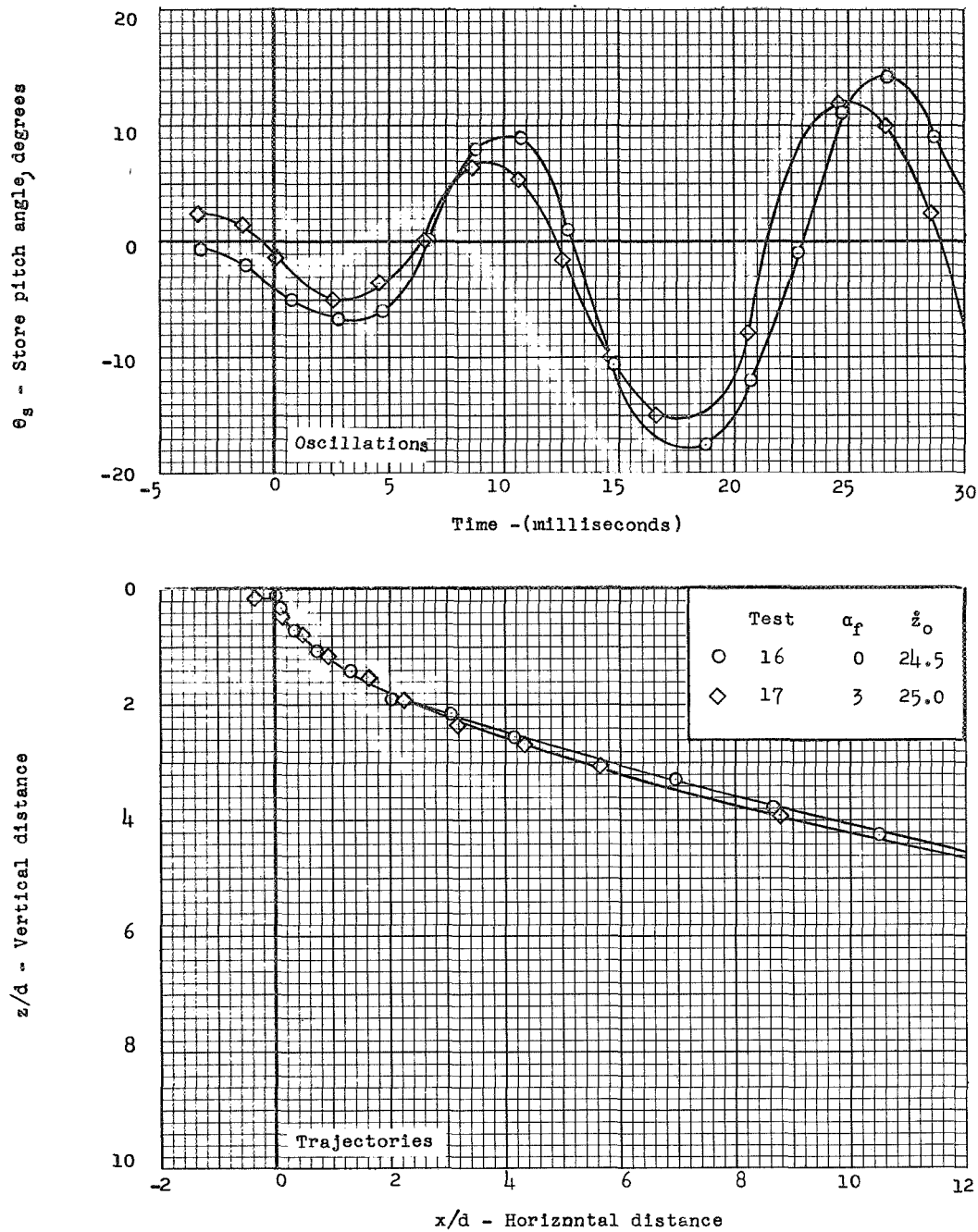
(e) Ejections with fin modifications at $\alpha_f = 0^\circ$ and $i_0 = -4^\circ$ and velocity changes.

Figure 16.- Continued.



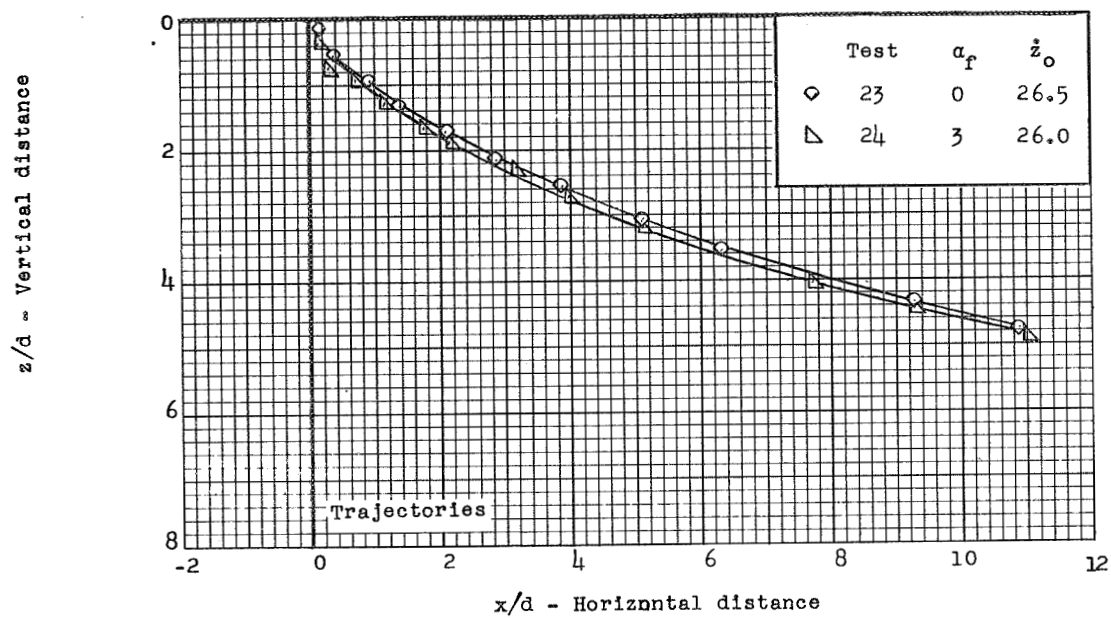
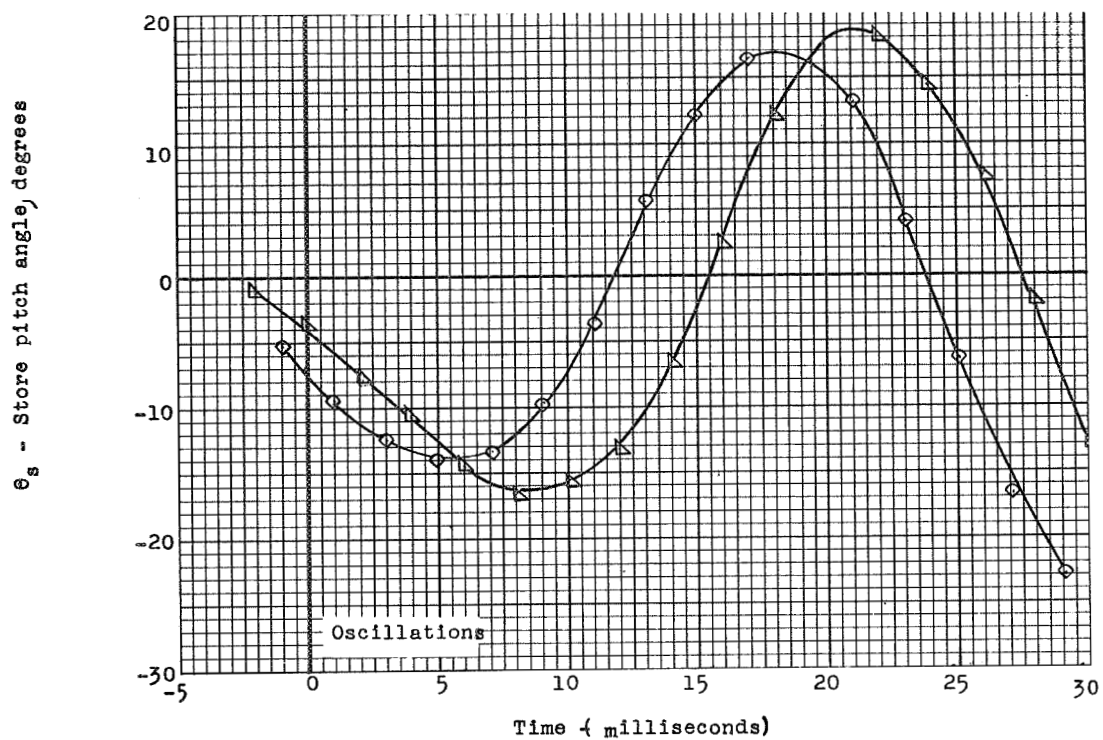
(f) Comparison of changes in α_f with standard fins at $\dot{z}_0 = 30$ feet per second.

Figure 16.- Concluded.



(a) $M_0 = 1.39$; $h_p = 3,400$ feet.

Figure 17.- Bluff-store oscillations and trajectories for a full guided stroke with ejector 1 and $i_0 = 0^\circ$ with change in α_f .



(b) $M_0 = 1.98$; $h_p = 29,000$ feet.

Figure 17.- Concluded.

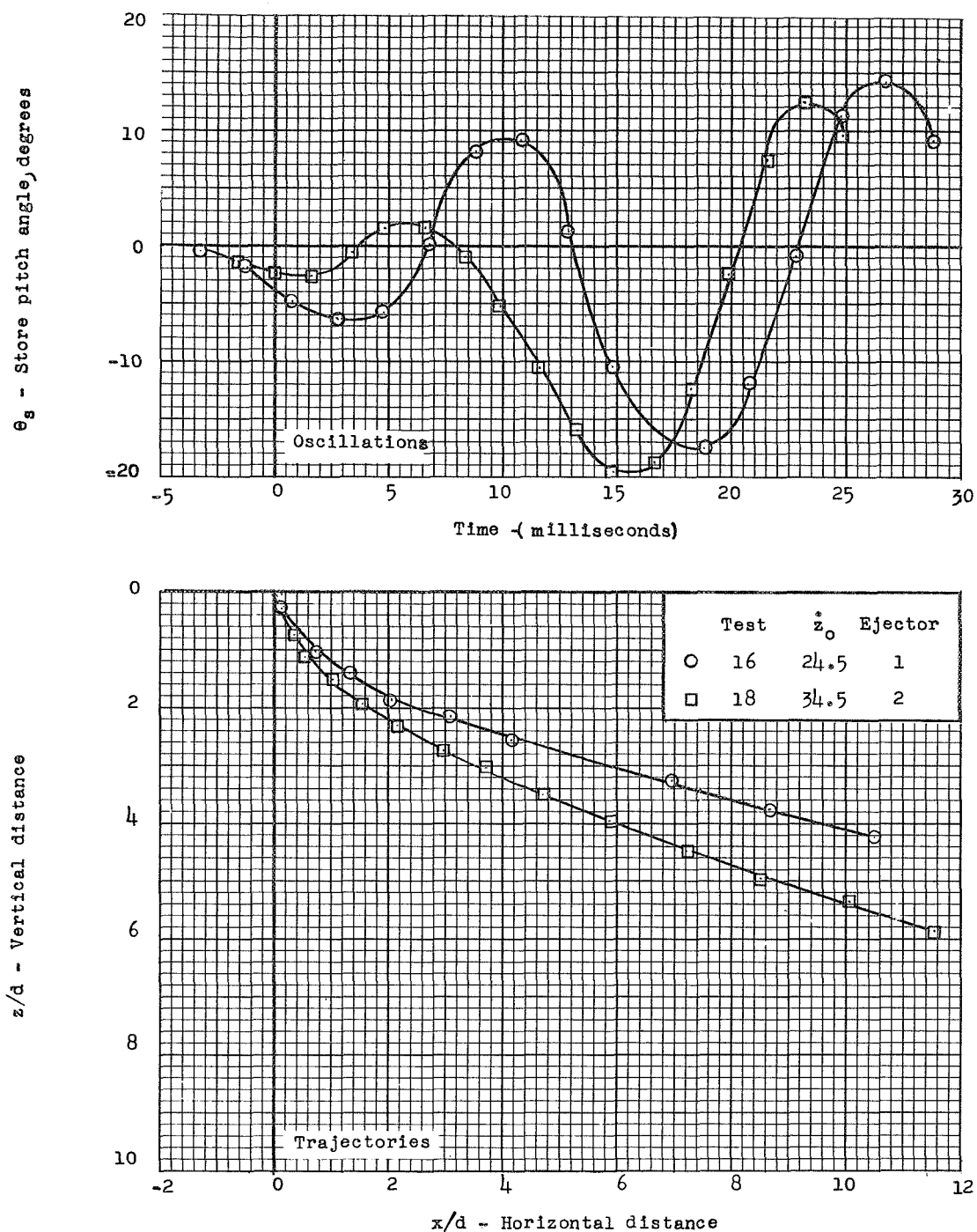
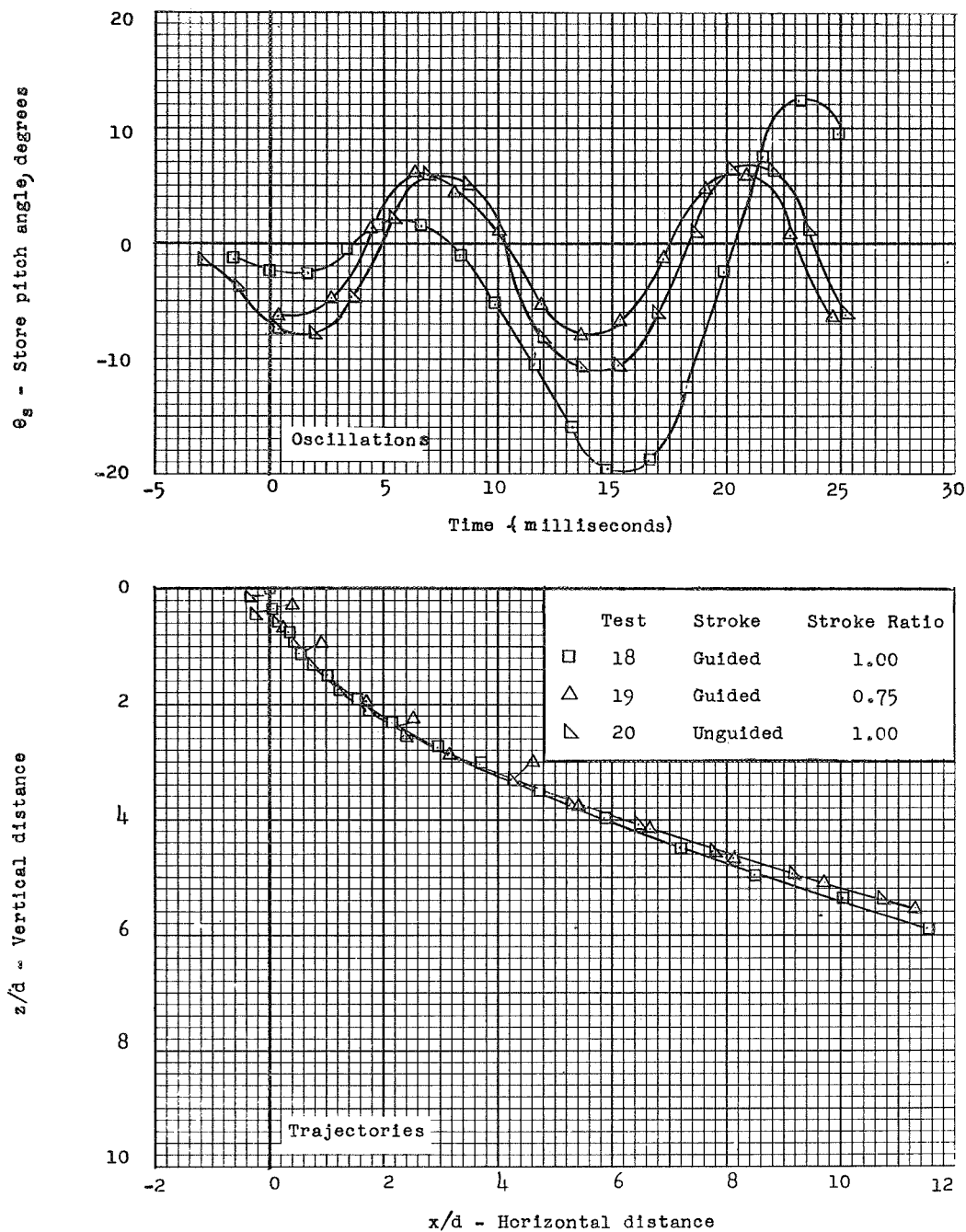
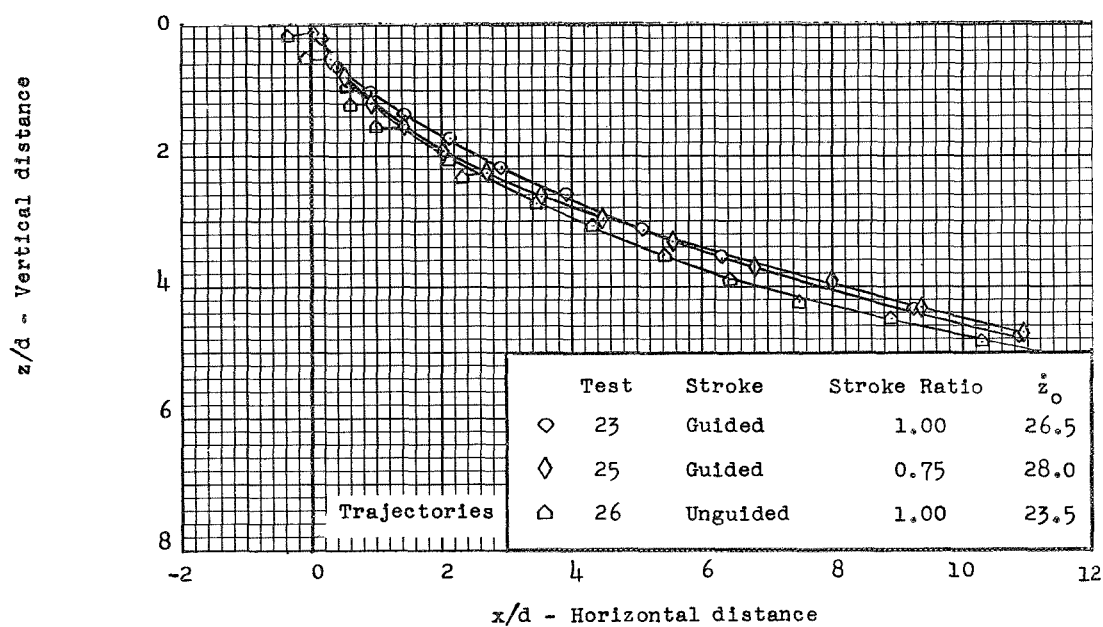
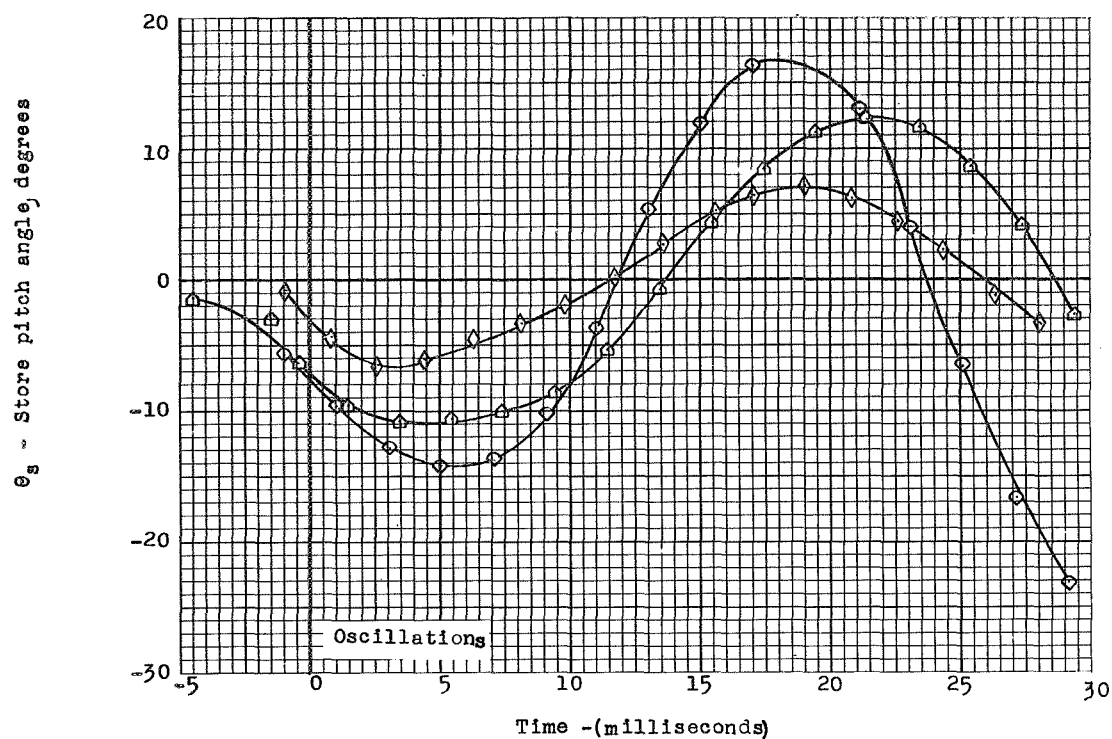


Figure 18.- Bluff-store oscillations and trajectories for a full guided stroke at $M_0 = 1.39$. $h_p = 3,400$ feet; $\alpha_f = 0^\circ$; and $i_0 = 0^\circ$ with change in ejection velocity.



(a) $M_0 = 1.39$; $h_p = 3,400$ feet; $\dot{z}_0 = 34$ feet per second.

Figure 19.- Bluff-store oscillations and trajectories at $\alpha_f = 0^\circ$, with ejector 2, for guided and unguided strokes and change in stroke ratio.



(b) $M_0 = 1.98$; $h_p = 29,000$ feet.

Figure 19.- Concluded.

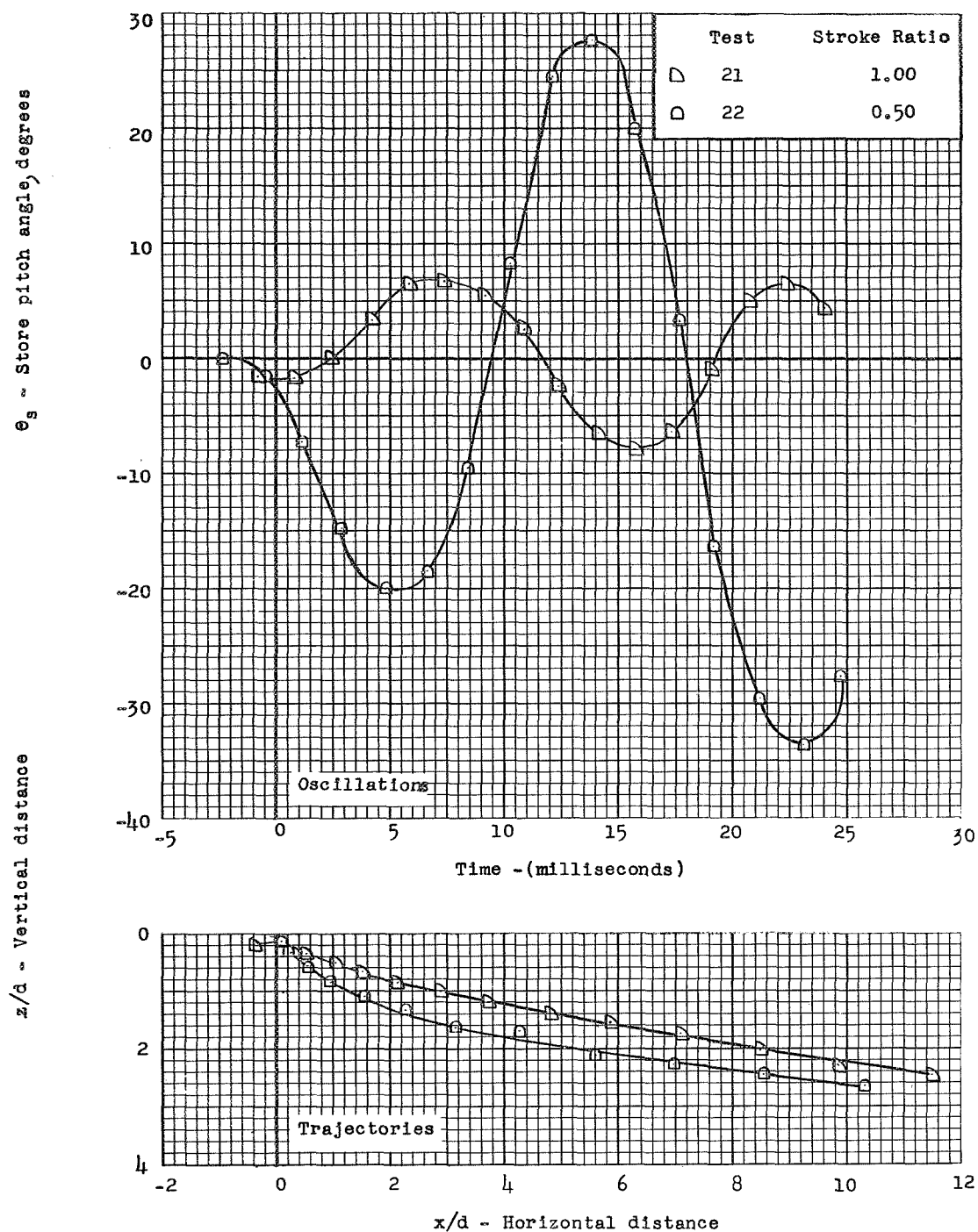


Figure 20.- Bluff-store oscillations and trajectories at $M_0 = 1.39$.
 $h_p = 3,400$ feet; $\alpha_F = 0^\circ$; and $\dot{z}_0 = 12.5$ feet per second; for 0.50
 and 1.00 guided stroke ratios.

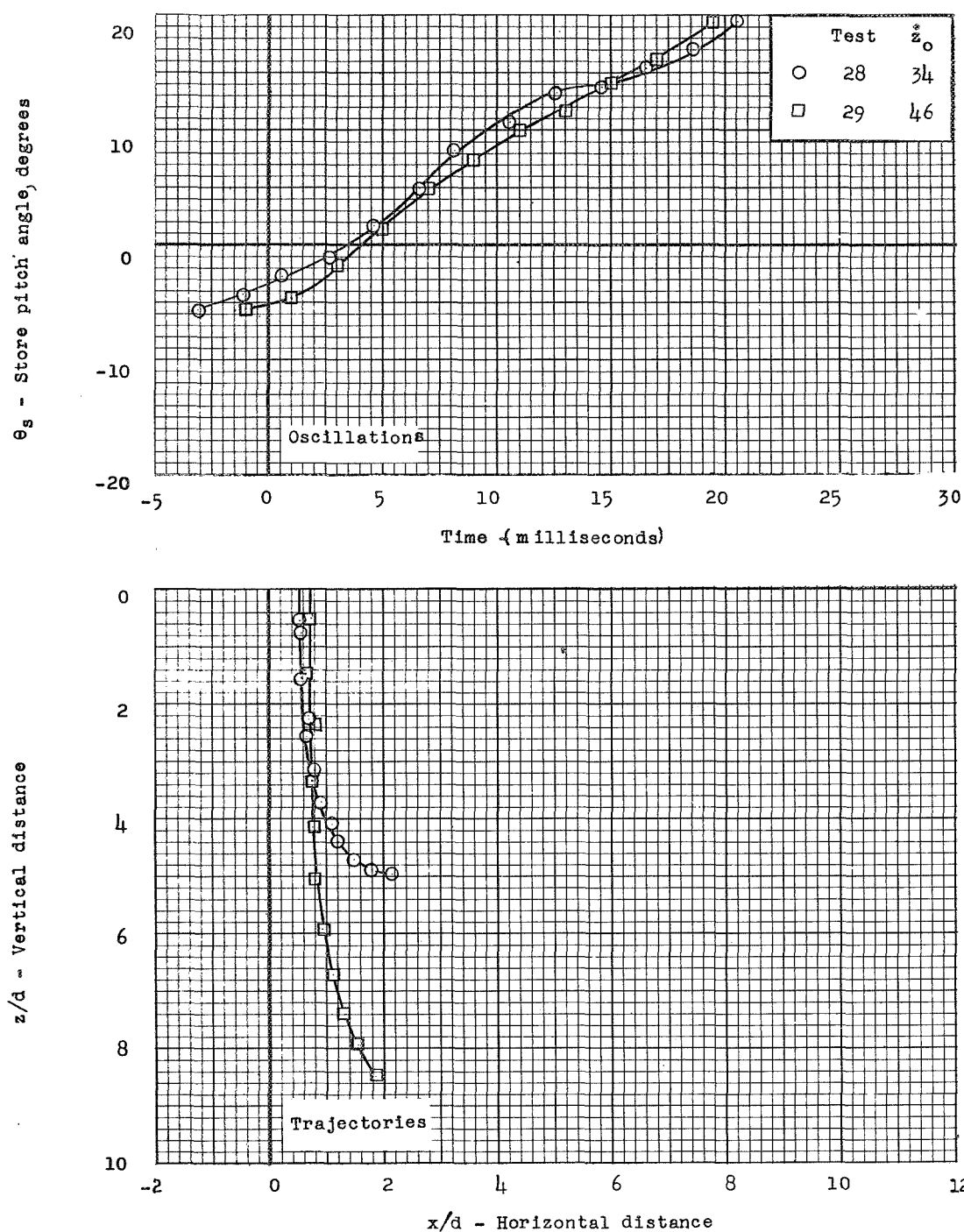


Figure 21.- TX-28 store oscillations and trajectories at $M_0 = 1.39$.
 $h_p = 3,400$ feet; $\alpha_F = 0^\circ$; and $i_0 = -4^\circ$ with change in ejection velocities.

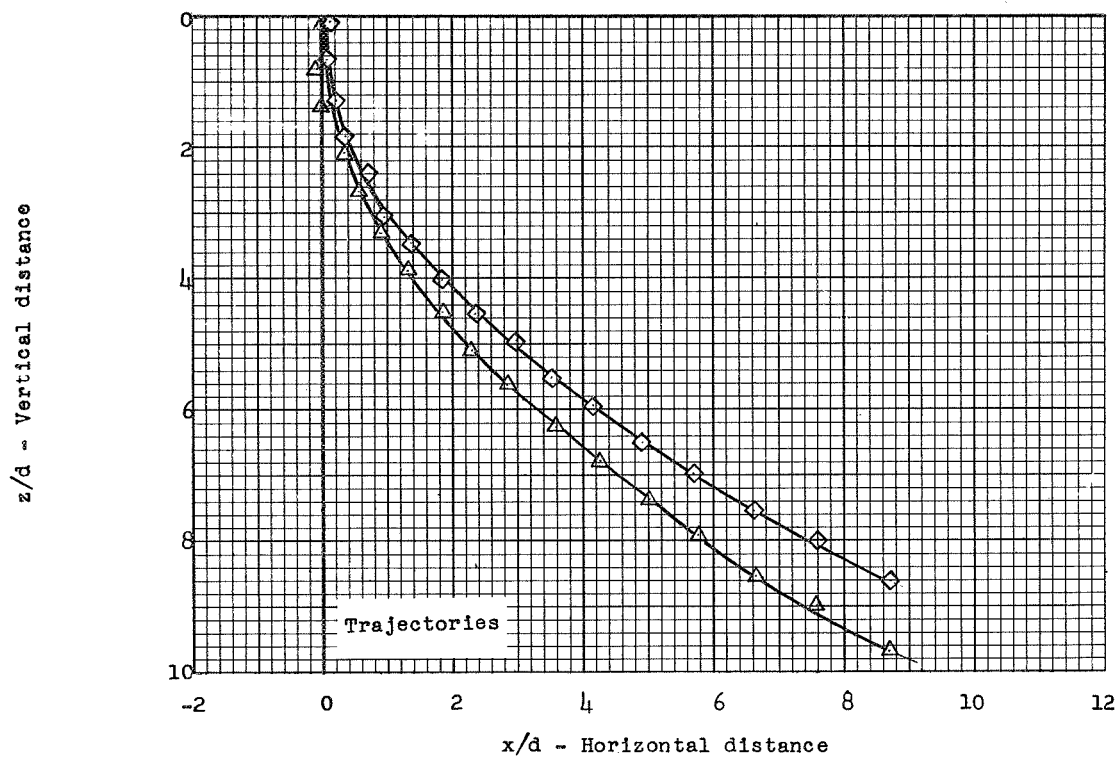
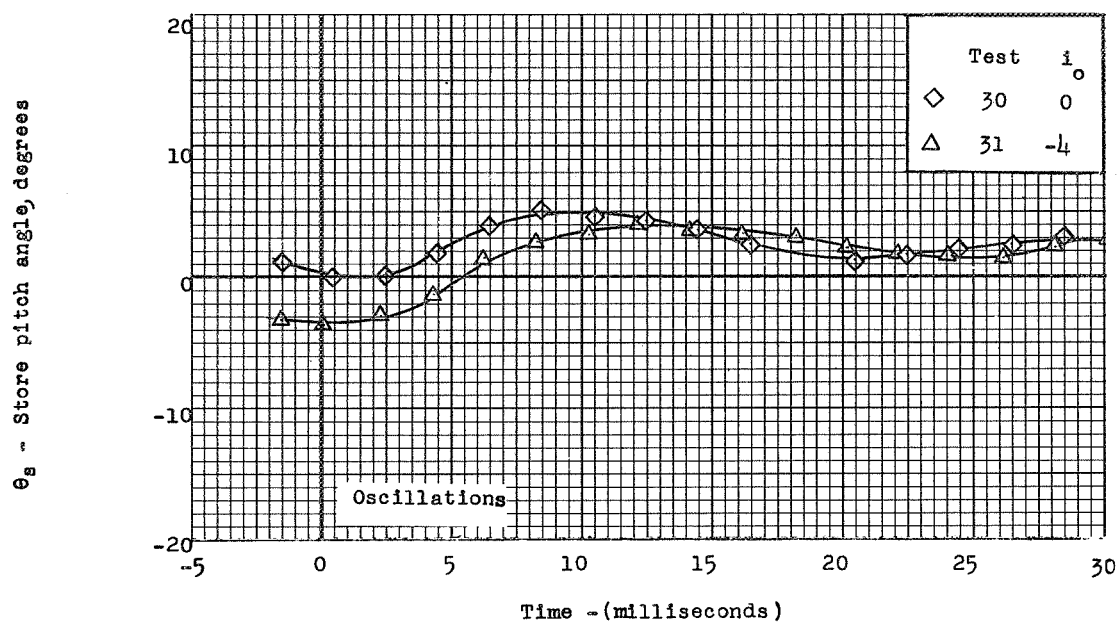


Figure 22.- Turnabout TX-28 store oscillations and trajectories at $M_0 = 1.39$, $h_p = 3,400$ feet; $\dot{z}_0 = 27.5$ feet per second; and $\alpha_f = 0^\circ$ with change in i_0 .

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ABSTRACT

A dynamic investigation of store ejections from a 1/17-scale bomb bay of the Republic F-105 airplane has been conducted in the 27- by 27-inch preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va., at Mach numbers of 1.39 and 1.98. A modified Mk-7 store, a bluff store, a TX-28 store, and a turnabout TX-28 store were ejected over a range of ejection velocities from 12.5 to 46 feet per second. The purpose of the investigation was to determine what first-order effects were involved in making these store ejections and to ascertain which modifications might be used to obtain successful releases near sea level.



Restriction/Classification Cancelled

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